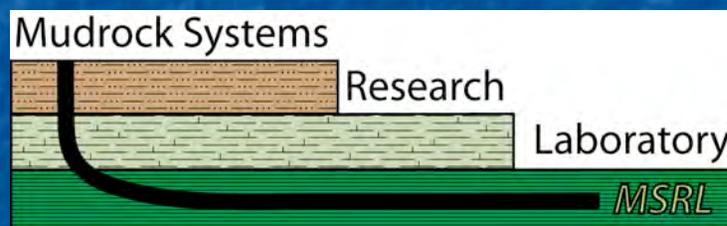


The Mudrock Systems Research Laboratory MSRL

A Multi-disciplinary Industrial Consortium

Stephen C. Ruppel
Principal Investigator



BUREAU OF
ECONOMIC
GEOLOGY

Bureau of Economic Geology
The Jackson School of Geosciences
The University of Texas at Austin
Scott Tinker, Director

THE UNIVERSITY OF TEXAS AT AUSTIN
JACKSON
SCHOOL OF GEOSCIENCES

Executive Summary

- The Bureau of Economic Geology has begun a new industrial consortium in mudrocks (gas shale) characterization and research
- Research **integrates** a wide spectrum of disciplines ranging from sedimentology to gas chemistry to fractures to fluid flow.
- Researchers include geoscientists and engineers from the Bureau and from affiliated organizations
- The program is funded by member O&G industry sponsors
- Membership cost is \$50,000 per year
- Member benefits include:
 - Exclusive priority access to data & reports
 - Attendance at annual meetings, short course, & workshops
 - Direct access to program researchers
 - Input on scope and focus of research
- Start: 2009; Continuing on annual basis

Mudrock Systems Research Laboratory (MSRL)

Some Key Research Questions

- What is the size, distribution, and abundance of mudrock pores?
- What controls hydrocarbon storage and flow?
- How do mudrock attributes vary in space and time (e.g., texture, fabric, mineralogy, porosity, fractures, mechanical properties)?
- What effect does variability have on hydrocarbon production?
- How can variability in rock and fluid properties be defined?
- How can measurements of complex rock attributes be upscaled to reservoir scales and applied?
- Which, if any, existing methodologies are applicable to mudrocks?

MSRL Goals

Develop **new paradigms for interpretation and analysis** of mudrocks. This will be accomplished through **integrated, multidisciplinary analysis of cores, outcrops, and geophysical data** from a variety of mudrock systems using observation, analysis, and testing at a range of scales.

Research Elements

•Rock Attributes

- Facies character and distribution
- Regional and reservoir-scale architecture
- Clay and silica diagenesis, compaction and cementation
- Elemental composition and depositional and diagenetic origins
- Pore systems: imaging, size, abundance, and distribution
- Kerogen distribution and thermal maturity

•Upscaling

- Wireline log & 3D calibration

- Rock mechanics**: geomechanical properties & their controls
- Hydrocarbon chemistry**: origin, storage, and distribution
- Fluid flow**: modeling of nano-scale permeability and flow
- Engineering**: relating production to rock attributes
- 3D geophysics**: rock attribute identification and mapping

Stratigraphic and Geographic Focus

Current Research Focus

- Barnett, Ft. Worth Basin
- Barnett, Permian Basin
- Woodford, Permian Basin
- New Albany, Illinois Basin
- Haynesville Shale, Texas, Louisiana
- Eagle Ford Shale, South Texas
- Pearsall Shale, Gulf Coast Basin
- Bakken Shale, Williston Basin
- Tuscaloosa, Gulf Coast Basin
- Zechstein succession (Europe)
- Hybrid Systems: “Wolfberry”, “Wolfbone”, Permian Basin

New and Planned Research Focus

- Floyd Shale, Black Warrior Basin
- Woodford, Anadarko Basin
- Duvernay, Canadian Basin
- Cline, Permian Basin

Methods and Instrumentation

- **Nanopore analysis:** Field emission SEM microscopy, Ar-ion milling, atomic force microscopy, N² adsorption/desorption
- Elemental and mineralogical composition:** XRF, XRD, Field emission SEM, cathodoluminescence & light microscopy, Gas MS
- **Fluid-flow modeling:** atomic force microscopy
- **Organic matter and hydrocarbon analysis:** Rock Eval, GC, GCMS, $\delta^{13}\text{C}$, SARA, vitrinite reflectance, kerogen analysis, carbon coulometry
- **Attribute distribution:** integrated outcrop, core, and geophysical analysis
- **Rock mechanics and fractures:** integrated core study and basin history modeling, strength testing.
- **Seismic attributes:** analysis and modeling

Key MSRL Research Staff

- 17 Bureau of Economic Geology Researchers
- 7 Researchers from Affiliated Organizations
- 15 Graduate & Post-doctoral Students

Stephen C. Ruppel

Ph.D., Senior Research Scientist, B.E.G



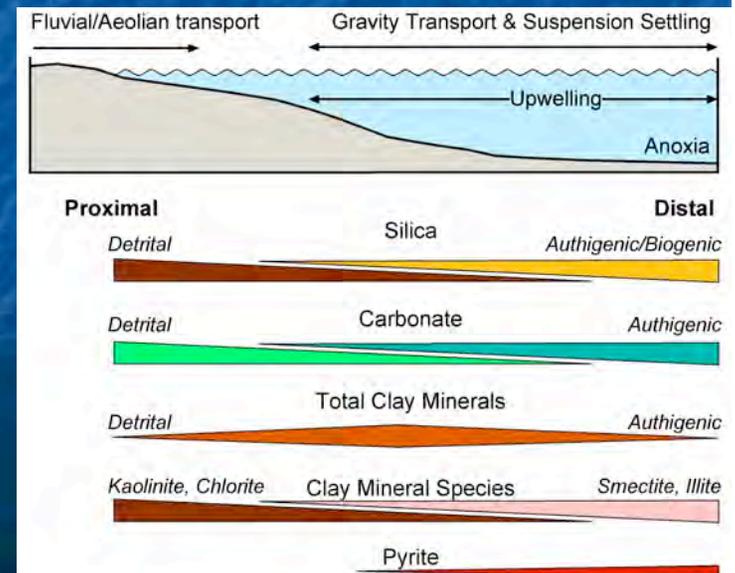
- Principal Investigator (Program Leader)

- Research Focus

- Sequence stratigraphy
- Intra- and inter-basinal rock attribute distribution
- Wireline log attributes & calibration
- Depositional & rock attribute models

- Current Stratigraphic and Geographic Focus

- Eagle Ford, Subsurface & Outcrops, South Texas
- Woodford Shale; Permian & Ft. Worth basins
- Barnett Shale; Permian & Ft. Worth basins
- Bakken, Williston Basin

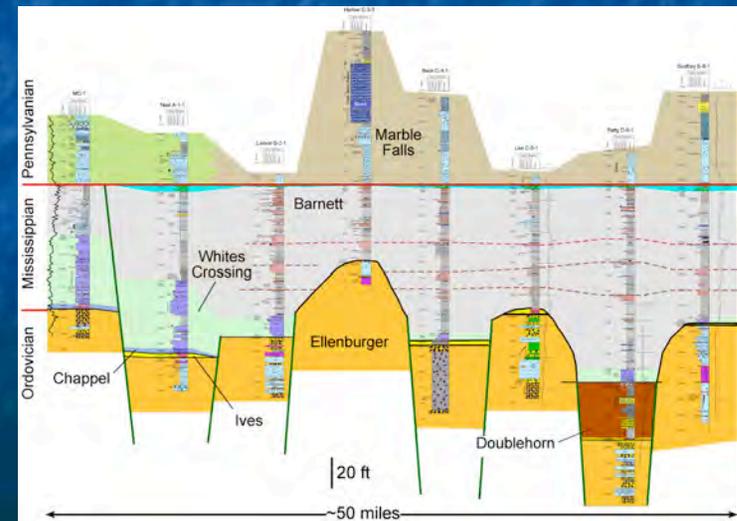


Robert Loucks

Ph.D., Senior Research Scientist, B.E.G



- Co-Principal Investigator of Bureau RCRL Program
- Research Focus
 - Sedimentology and stratigraphy
 - Depositional facies and paleo-environments
 - Pore system analysis
- Current Stratigraphic and Geographic Focus
 - Barnett; Ft. Worth Basin
 - Pearsall, Gulf Coast Basin
 - Eagle Ford outcrops, west Texas

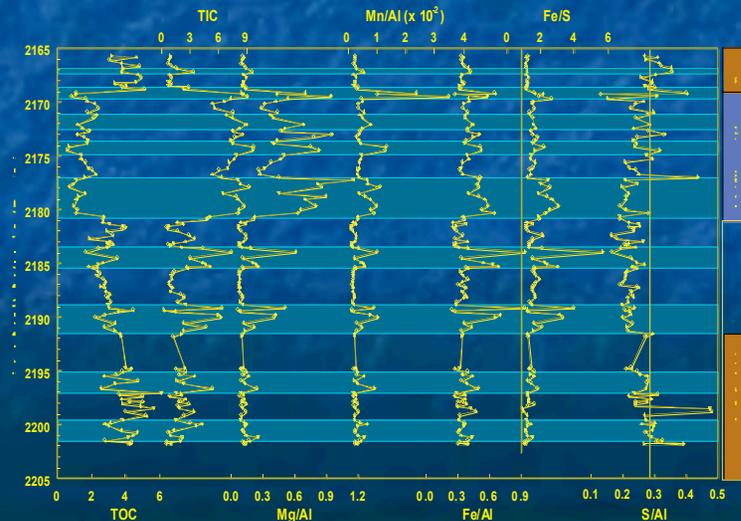


Harry Rowe

Ph.D., Research Scientist, B.E.G



- **Director: Elemental and Isotope chemistry labs**
- **Research Focus**
 - Chemical basin evolution
 - Chemostratigraphy
 - Stable Isotope Chemistry
- **Current Stratigraphic and Geographic Focus**
 - Barnett; Ft. Worth and Permian basins
 - Woodford; Permian Basin
 - Ohio Shale, Appalachian Basin
 - New Albany Shale, Illinois Basin
 - Smithwick Shale, Ft. Worth basin
 - Eagle Ford Shale, Gulf Coast Basin
 - Marcellus, NE US
 - Many other shales

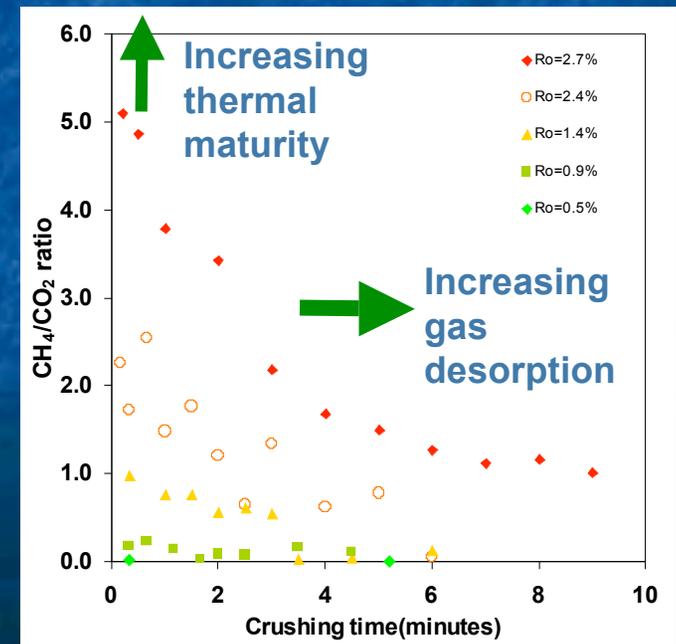


Tongwei Zhang

Ph.D., Research Associate, B.E.G



- Director: Hydrocarbon Geochemistry Lab
- Research Focus
 - Hydrocarbon chemistry
 - Organic chemistry
 - Gas Resource Analysis
 - Hydrocarbon flow modeling
- Current Stratigraphic and Geographic Focus
 - Barnett Shale; Permian & Ft. Worth basins
 - Haynesville
 - Eagle Ford
 - Woodford
 - Bakken

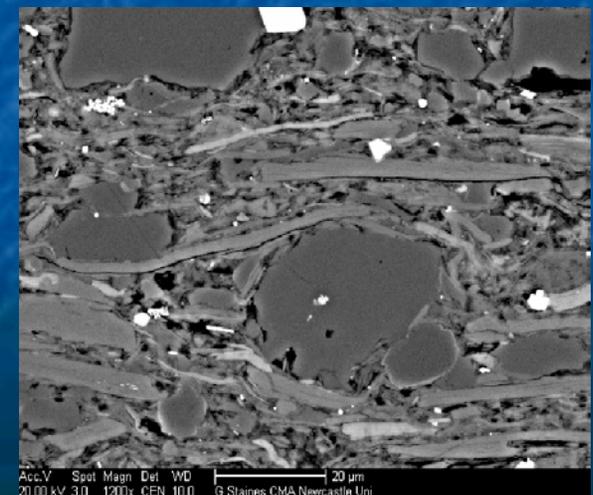


Kitty L. Milliken

Ph.D., Senior Research Scientist, B.E.G

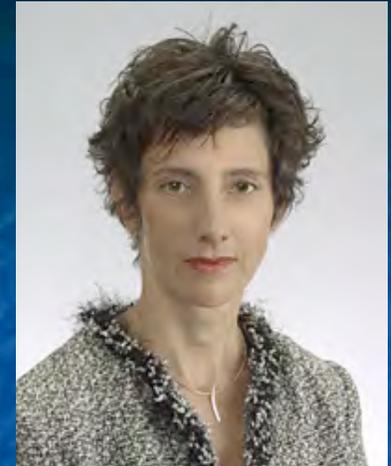


- **Manager: Micro-Beam Lab**
- **Research Focus**
 - Lithologic heterogeneity
 - Silica diagenesis
 - Micro-facies analysis
 - Pore system analysis
- **Current Stratigraphic and Geographic Focus**
 - Barnett Shale; Ft. Worth Basin
 - Modern oceanic mudrock systems
 - Pearsall shale, Gulf Basin
 - Eagle Ford, South Texas Basin



Ursula Hammes

Ph.D., Research Associate, B.E.G

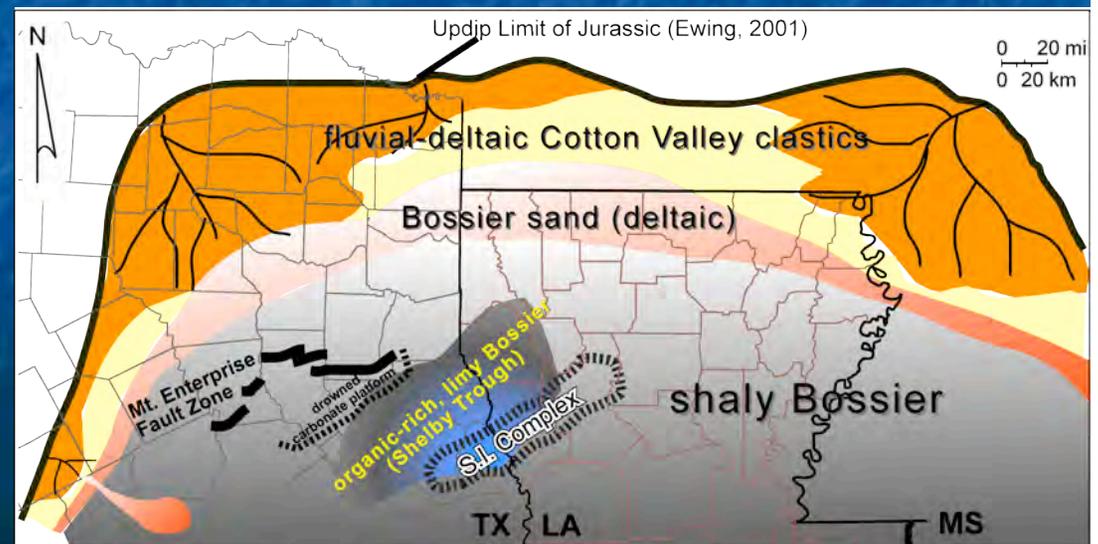


•Research Focus

- Stratigraphy and sedimentology
- Rock attribute distribution

•Current Stratigraphic and Geographic Focus

- Haynesville, East Texas Basin
- Zechstein Basin



H. Seay Nance

Ph.D., Research Associate, B.E.G

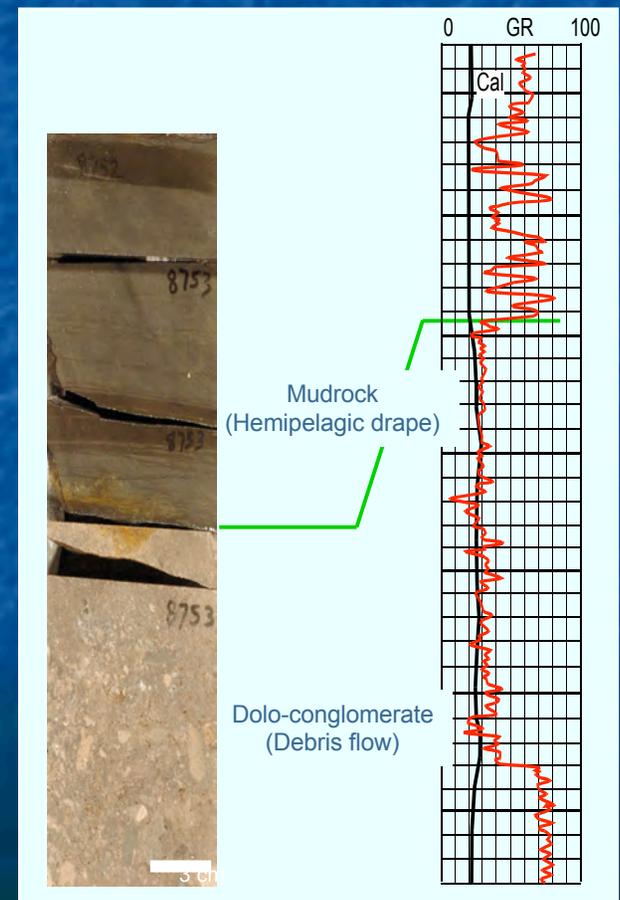


•Research Focus

- Stratigraphy & Sedimentology
- Rock attribute distribution

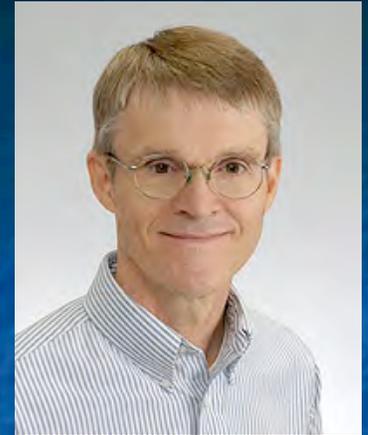
•Current Stratigraphic and Geographic Focus

- Bone Spring Fm, Permian Basin
- “Wolfbone”, Permian Basin
- Other Permian Basin shale systems



H. Scott Hamlin

Ph.D., Research Associate, B.E.G

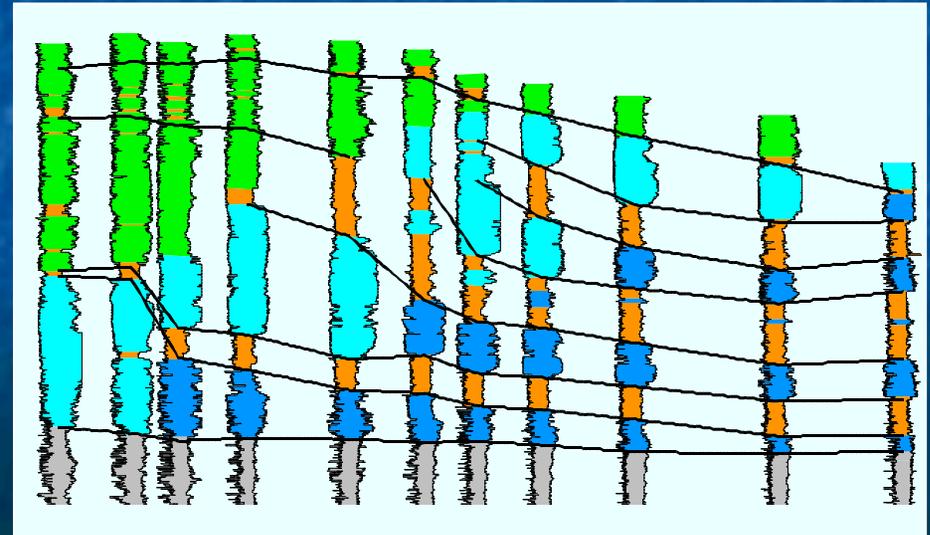


•Research Focus

- Stratigraphy & Sedimentology
- Rock attribute distribution

•Current Stratigraphic and Geographic Focus

- Haynesville, East Texas
- Spraberry Fm, Permian Basin
- “Wolfberry”, Permian Basin
- Smithwick Fm, Ft. Worth Basin



Robert Reed

Ph.D., Research Associate, B.E.G

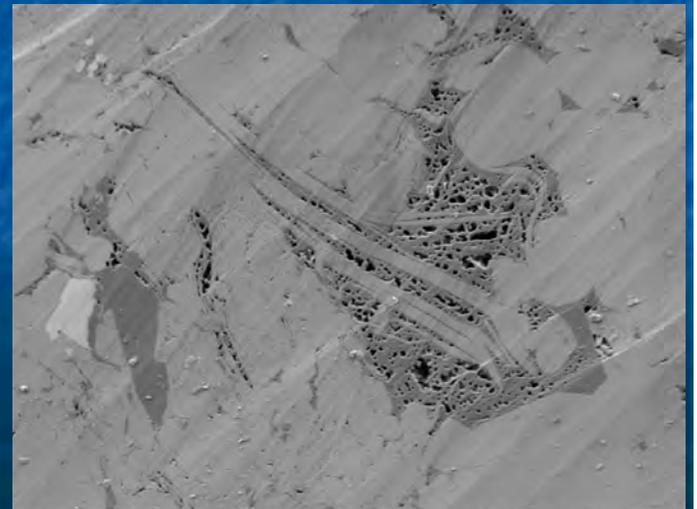


•Research Focus

- Nano-scale pore imaging
- Elemental analysis

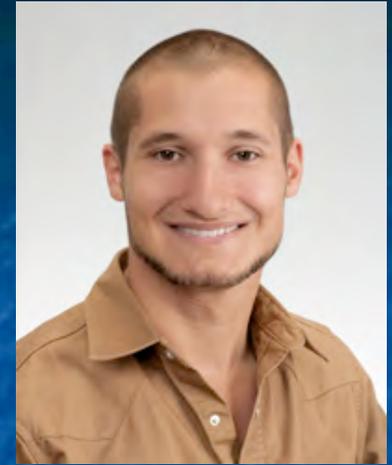
•Current Stratigraphic and Geographic Focus

- Woodford; Permian & Ft. Worth basins
- Barnett; Permian & Ft. Worth basins
- Pennsylvanian: Ft. Worth Basin
- Haynesville Shale, East Texas
- Eagle Ford Shale, South Texas
- Many others



Gregory Frebourg

Ph.D., Research Associate, B.E.G



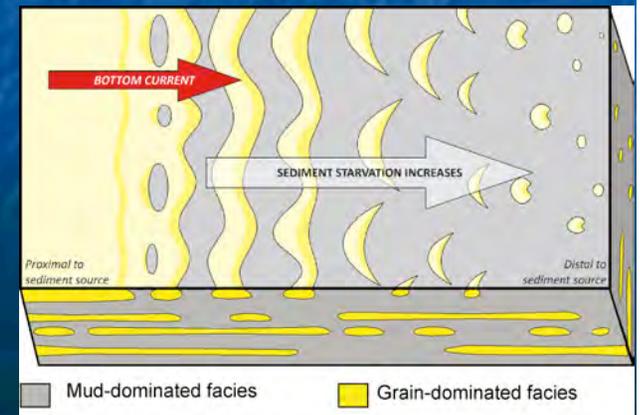
•Research Focus

- Sedimentology , depositional processes

•Current Stratigraphic and Geographic Focus

- Haynesville; East Texas Basin

- Eagle Ford; outcrops and subsurface



Robert Baumgardner

M.S., Research Scientist Associate, B.E.G



- Research Focus

- Sedimentology, Stratigraphy

- Current Stratigraphic and Geographic Focus

- Wolfcamp shales, Permian Basin

- Other Permian Basin shales

Tucker Hentz

M.S., Research Scientist Associate, B.E.G.

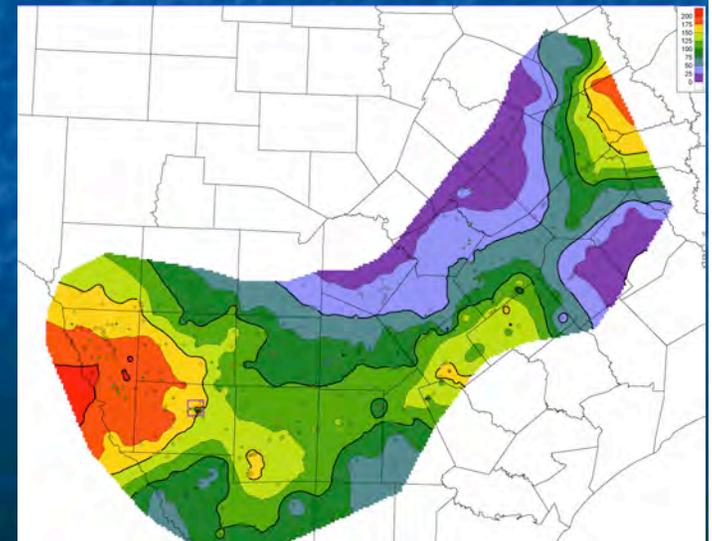


- Research Focus

- Stratigraphy

- Current Stratigraphic and Geographic Focus

- Eagle Ford shale, Gulf Basin
- Pearsall shale, Gulf Basin
- Atoka system, Ft. Worth Basin

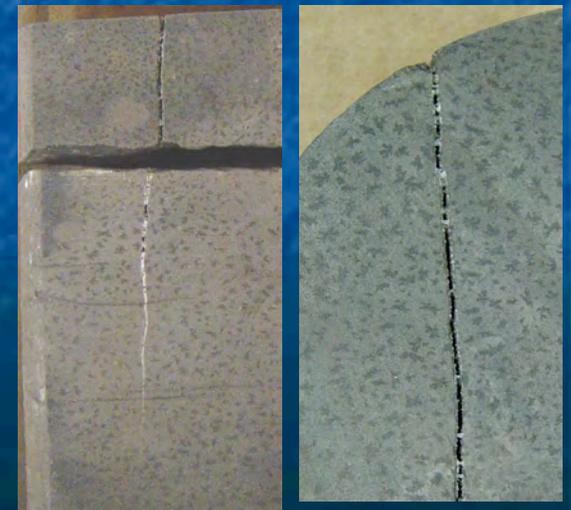


Julia Gale

Ph.D., Research Scientist, B.E.G



- **Lead Fracture Analysis Scientist**
- **Research Focus**
 - Fracture development
 - Evolution of geomechanical properties
 - Basin History
- **Current Stratigraphic and Geographic Focus**
 - Woodford; Permian & Ft. Worth basins
 - Barnett; Permian & Ft. Worth basins
 - New Albany; Illinois Basin
 - Marcellus, North-central US



Farzam Javadpour

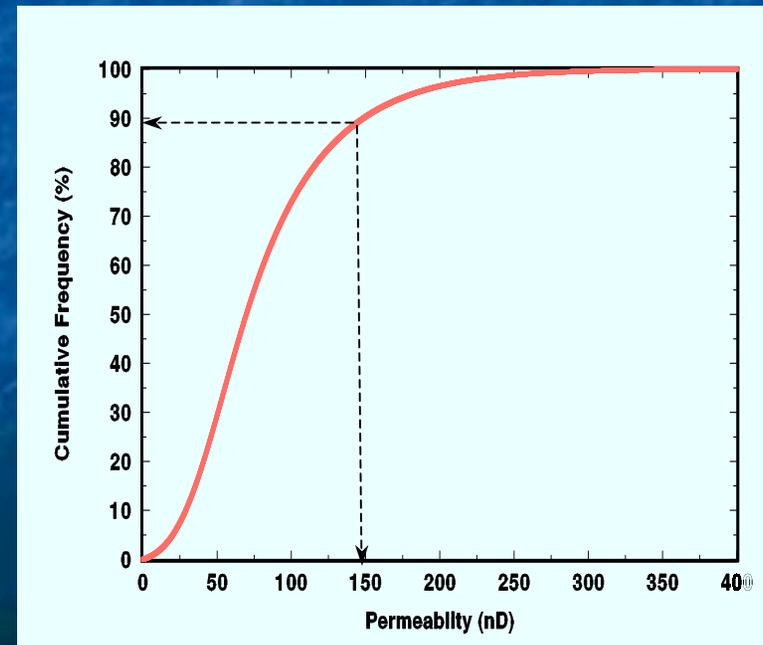
Ph.D., Research Associate, B.E.G



- Director: Atomic Force Microscopy Lab
- Research Focus
 - Fluid flow modeling
 - Atomic force microscopy
 - Non-Darcy Flow

Current Stratigraphic and Geographic Focus

- Barnett; Ft. Worth Basin
- Haynesville
- Eagle Ford



Fred Wang

Ph.D., Research Scientist, B.E.G

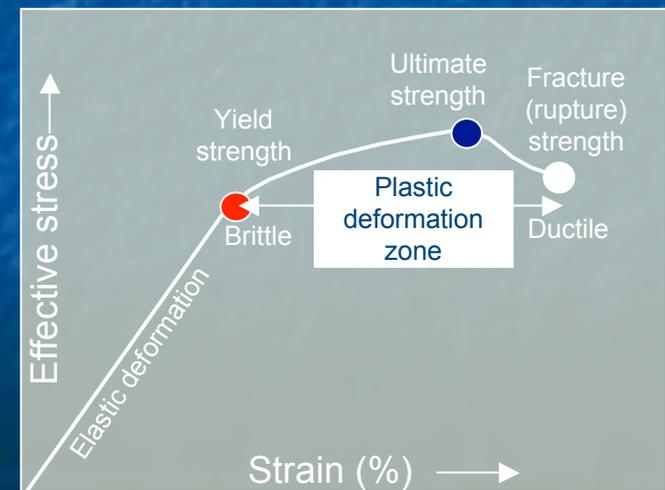


•Research Focus

- Integration of rock attributes and engineering
- Production engineering
- Brittleness

•Current Stratigraphic and Geographic Focus

- Barnett Shale; Ft. Worth basin
- Woodford Shale, Permian Basin
- Fayetteville Shale, Arkoma Basin
- Haynesville Shale, East Texas
- Eagle Ford Shale, Maverick Basin
- Other productive shale systems



Jiemin Lu

Ph.D., Research Associate, B.E.G



- Research Focus

- Geochemistry & Sedimentology

- Current Stratigraphic and Geographic Focus

- Tuscaloosa, Gulf Coast Basin

Hongliu Zeng

Ph.D., Senior Research Scientist, B.E.G

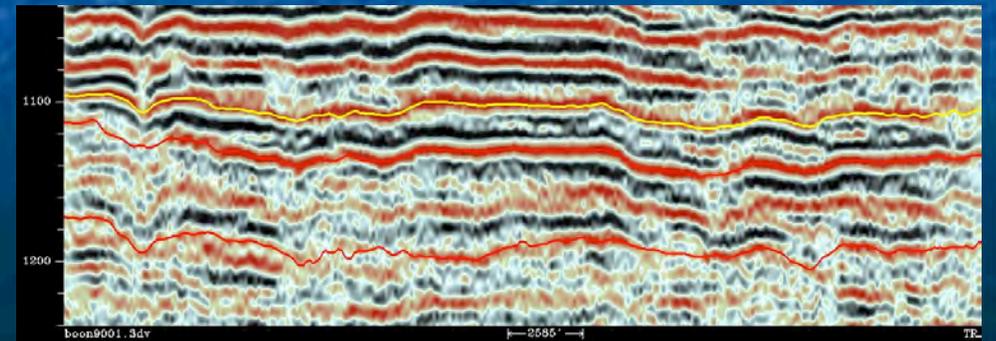


•Research Focus

- Geophysics & Geological Interpretation
- Stratal slicing

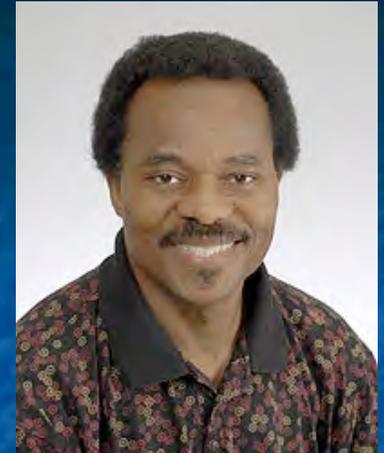
•Current Stratigraphic and Geographic Focus

- Barnett, Ft. Worth Basin
- Eagle Ford, South Texas



Chris Ogiesoba

Ph.D., Research Scientist, B.E.G

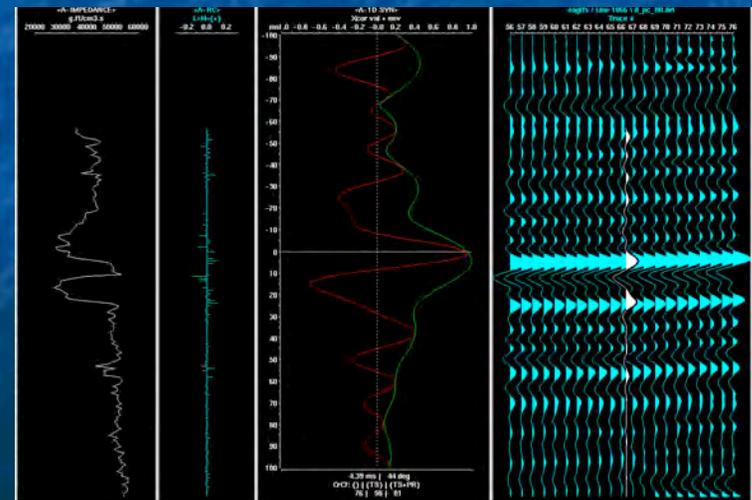


- **Research Focus**

- 3D geophysics
- Fault & attribute mapping

- **Current Stratigraphic and Geographic Focus**

- Eagle Ford shale, Gulf Basin



Cari Breton

B.A., Research Scientist Associate, B.E.G



- Research Focus

- GIS
- Data Base Management

- Current Focus

- ARC-GIS
- Web Database delivery systems

Necip Guven

Ph.D., Research Associate,
University of Texas, San Antonio

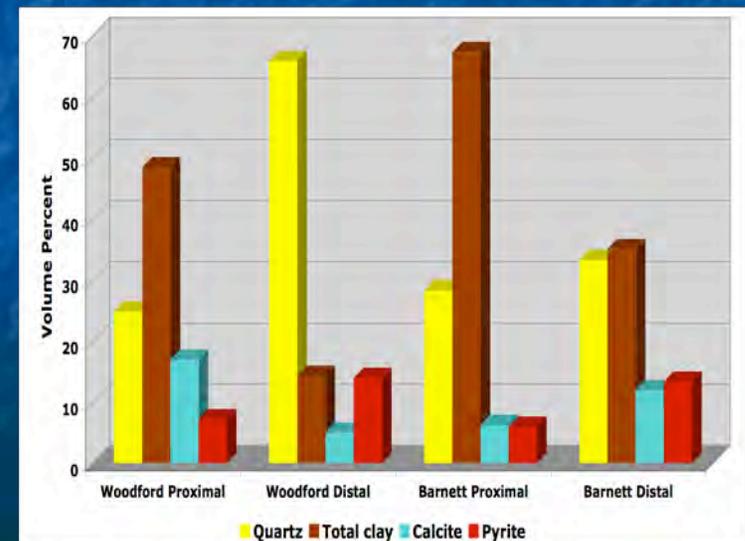


•Research Focus

- Clay mineralogy
- Elemental analysis
- X-ray diffraction

•Current Stratigraphic and Geographic Focus

- Barnett; Ft. Worth & Permian Basins
- Woodford, Permian Basin
- Haynesville, East Texas Basin
- Pearsall
- Eagle Ford
- Bone Spring
- Wolfberry
- Many others



Nick Hayman

Ph.D., Research Associate
Institute for Geophysics,
University of Texas



- **Research Focus**

- Mudrocks fabrics & diagenesis
- Rock and pore fluid properties

- **Stratigraphic and Geographic Focus**

- Pearsall, Gulf Coast Basin
- Nankai prism, Japan

Ray Eastwood

Consultant

- **Research Focus**

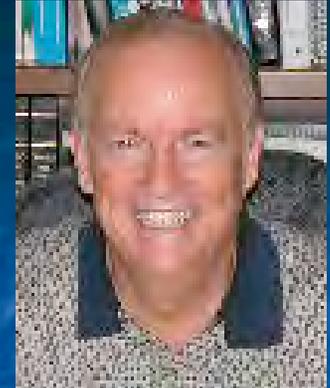
- Petrophysics
- Well log calibration
- Rock attribute modeling & prediction

- **Current Stratigraphic and Geographic Focus**

- Haynesville, East Texas Basin
- Eagle Ford, South Texas Basin
- Woodford, Permian Basin

Dan Jarvie

President, Worldwide Geochemistry



•Research Focus

- Rock Eval
- Gas chromatography
- Hydrocarbon chemistry
- Hydrocarbon generation

•Current Stratigraphic and Geographic Focus

- All mudrock systems

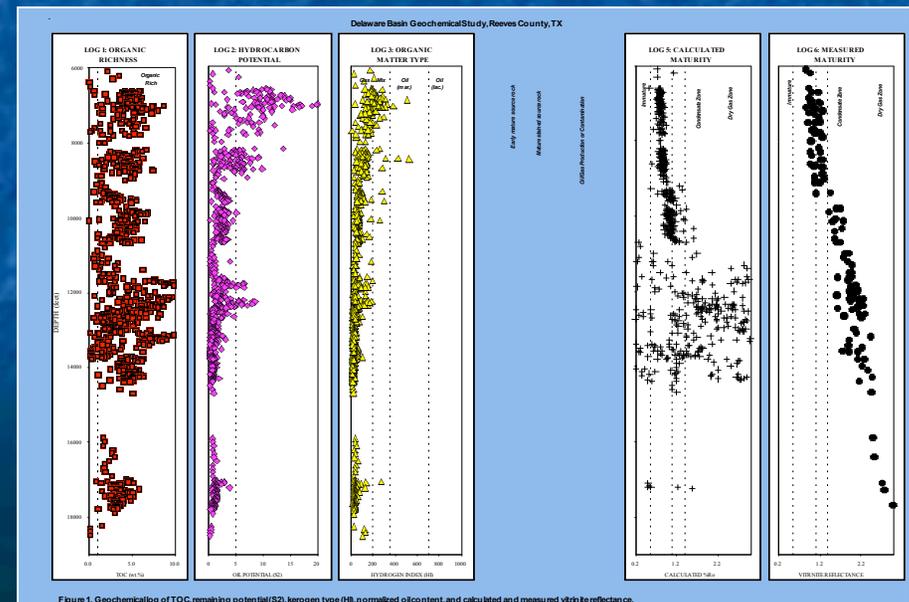


Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (H), normalized oil content, and calculated and measured vitrinite reflectance.

Jeff Over

Professor, SUNY Geneseo



- **Research Focus**

- Paleontology
- Conodont Biostratigraphy

- **Current Stratigraphic and Geographic Focus**

- Woodford Shale, Permian Basin
- Upper Devonian shales, US



Robert Tatham

Ph.D., Professor, University of Texas
Department of Geological Sciences



- **Research Focus**

- Multi-component Seismic
- Rock and pore fluid properties

- **Planned Stratigraphic and Geographic Focus**

- Barnett; Ft. Worth Basin, Permian Basin
- Woodford, Permian & Arkoma basins

Benefits of Membership

- Attendance at annual MSRL meetings and workshops
- Direct interaction with project staff
- Analysis of sponsor data sets
- Opportunity to guide scope and direction of consortium
- Exclusive access to project findings and data for minimum of 1 year
- Digital access to program data and results
- Opportunities for collaboration

Program Structure

- Annual membership/sponsorship fee: \$50,000 (Members joining after the first year will pay a premium for access to prior year data)
- Program start: January 1, 2009
- Program life: Continuing on annual basis

For Further Information

- **Stephen C. Ruppel (Principal Investigator)**
 - Email: stephen.ruppel@beg.utexas.edu
 - Phone: 512-471-2965

- **Robert Loucks**
 - Email: bob.loucks@beg.utexas.edu
 - Phone: 512-471-0366