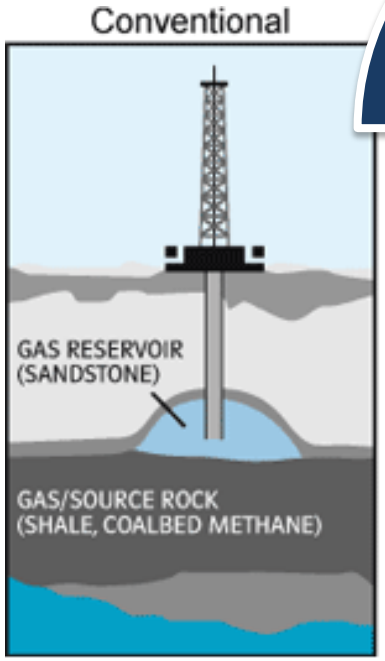
Role of Geochemistry in Unconventional Resource Development

Shikha Sharma

Dept. of Geology & Geography

SHARMA ISOTOPE LAB

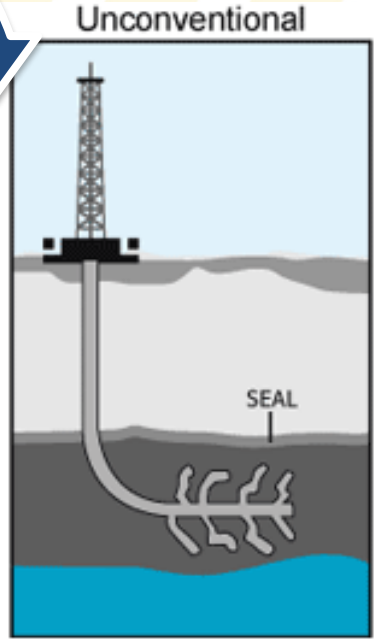
Role of Geochemistry



OPPORTUNITIES HAVE CHANGED

SOURCE = RESERVOIR

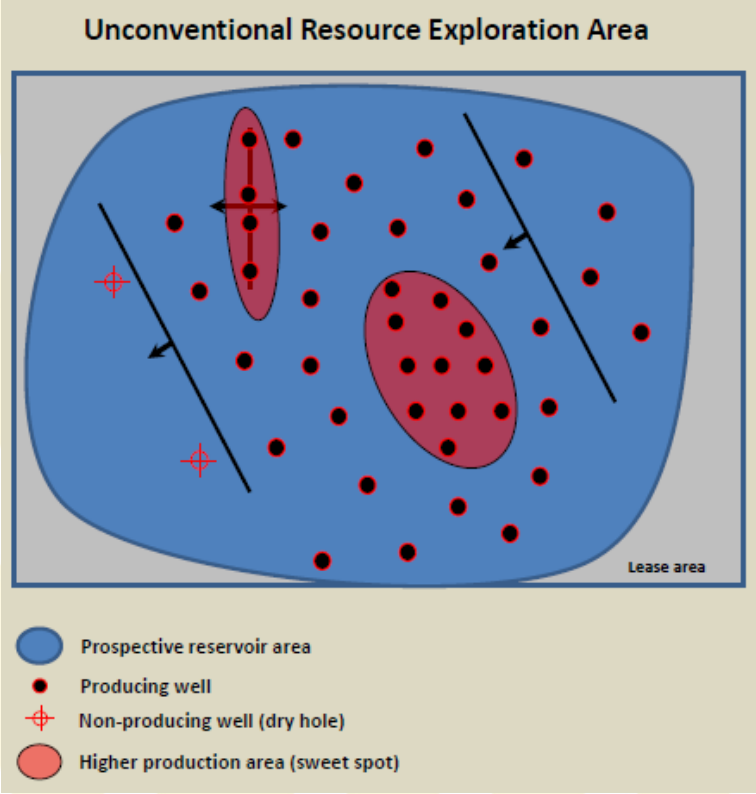
Need for understanding the geological and geochemical heterogeneities in source rock



Geochemistry Applications

1. Source Rock Characterization

1. Modelling Variations in TOC
    - Locating **sweet spots**
    - Oil vs gas production
    - Frackability
    - Porosity /permeability effects
2. Modelling variations in mineral and elemental composition
    - natural/induced fracture networks
    - rock-fluid interactions

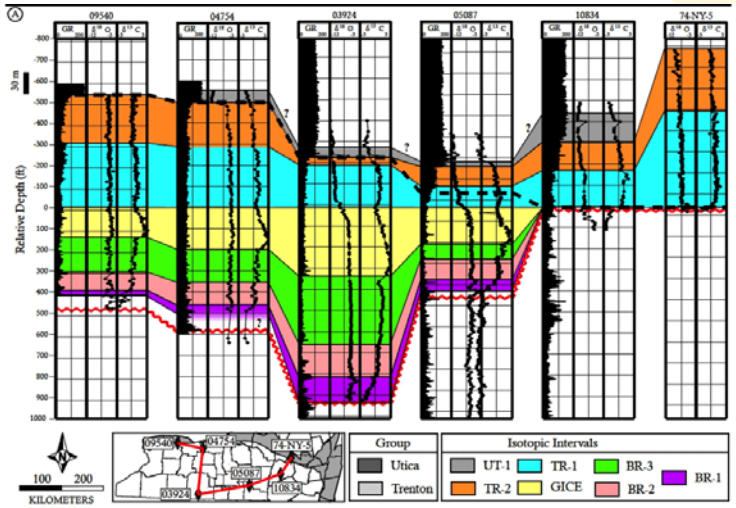


Source: Dawson Energy Advisors Ltd.

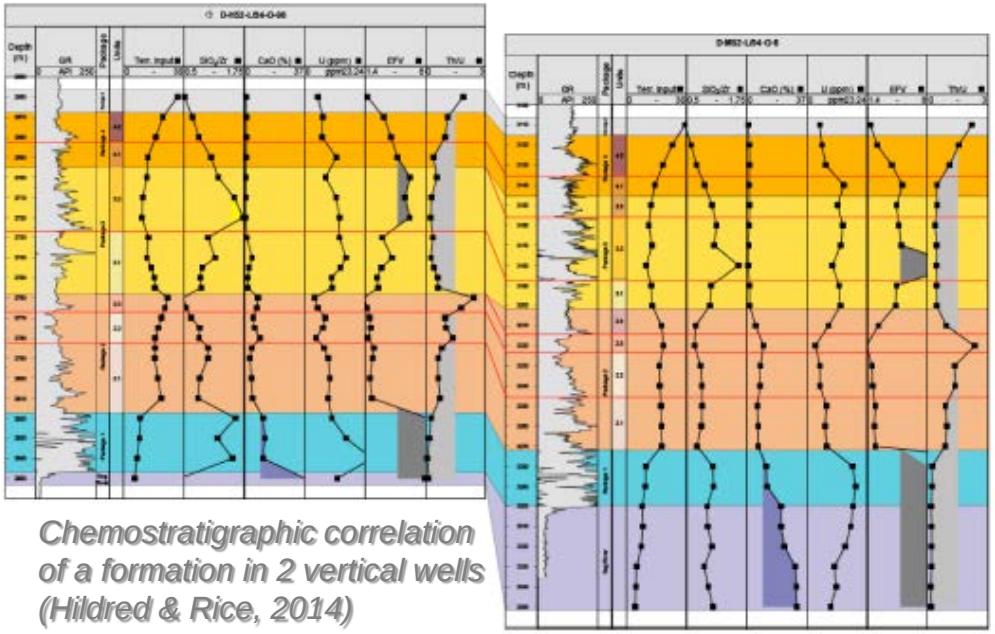
Geochemistry Applications

2. Chemostratigraphic Correlation

- Vertical and lateral continuity of reservoirs
- Placement of horizontal wells



Proposed correlations of the New York subsurface based on $\delta^{13}C_{carb}$ (Mitzger et. al., 2013)

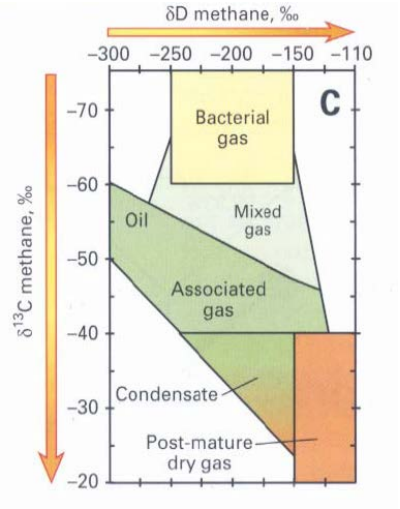


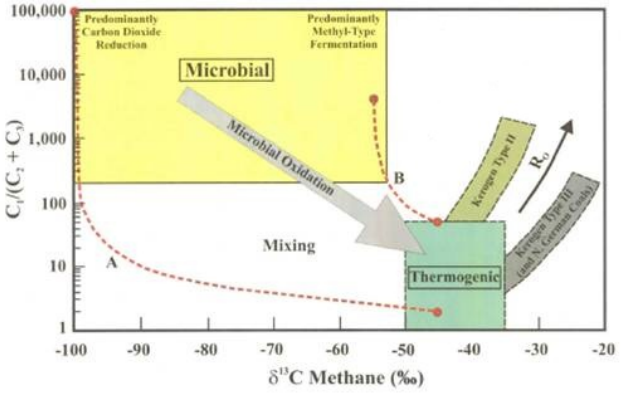
Chemostratigraphic correlation of a formation in 2 vertical wells (Hildred & Rice, 2014)

Geochemistry Applications

3. Determining Zonal Isolation

- Gas/fluid migration due to propagation of fractures into overlying or underlying zones
- Production allocation- Quantifying contribution of individual pay zones to comingled produced gas





Modified Schoell & Bernard plots

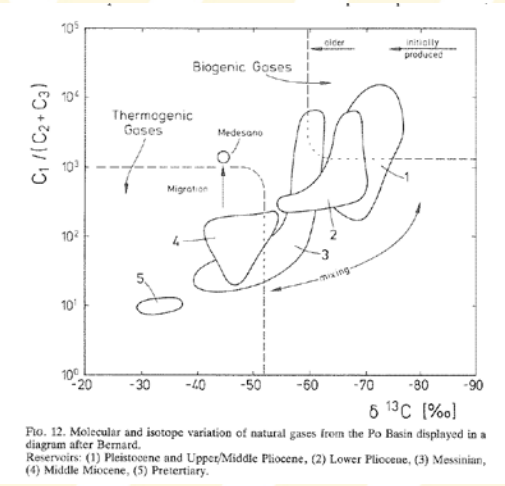
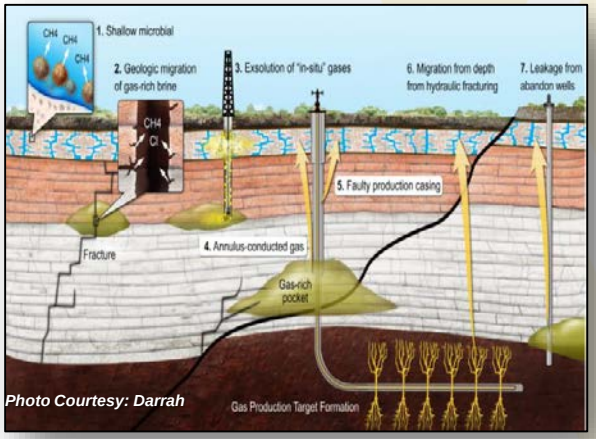


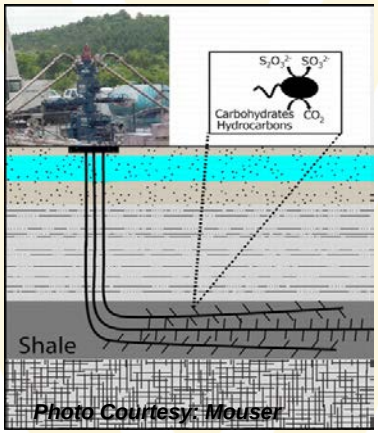
FIG. 12. Molecular and isotope variation of natural gases from the Po Basin displayed in a diagram after Bernard.
Reservoirs: (1) Pleistocene and Upper/Middle Pliocene, (2) Lower Pliocene, (3) Messinian, (4) Middle Miocene, (5) Pretertiary.

Geochemistry Applications

4. Assessing Environmental Impacts

- Determine if stray gas and/or pollutants in aquifers are associated with oil and gas development
- Assessing water-rock-microbe reactions after injection of hydraulic fracturing fluids and their impacts on well infrastructure, souring & in-situ production of organic contaminants

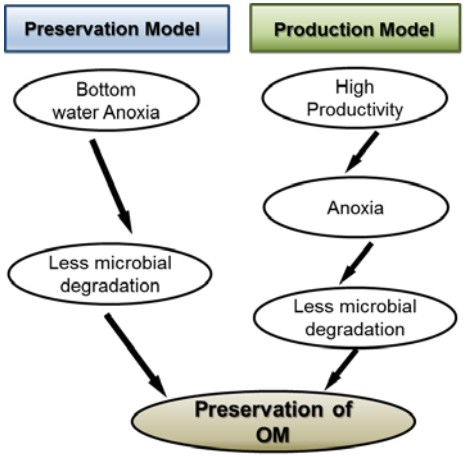


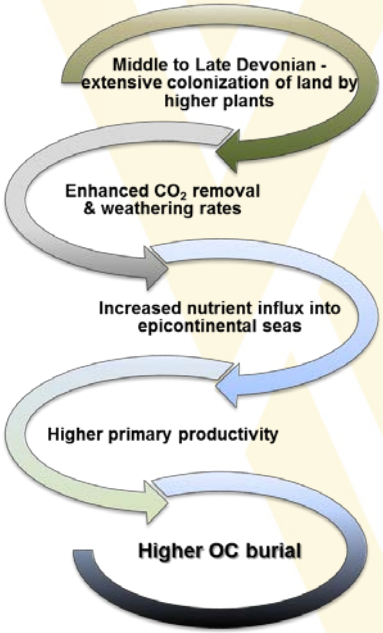


Source: ISOTECH

Source Rock Characterization

What are primary factors controlling variations in the quantity & quality of Total Organic Carbon (TOC) content in Marcellus Shale?

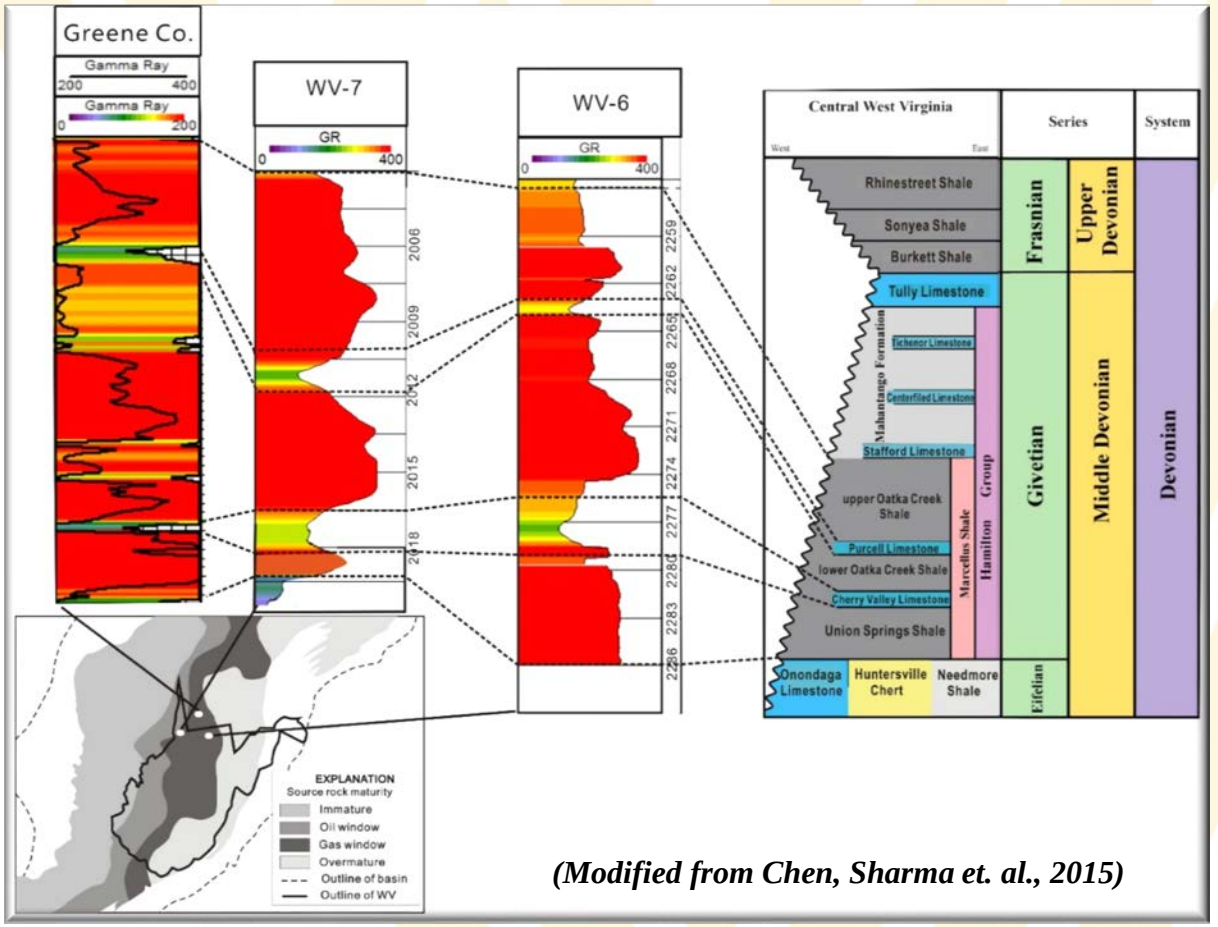




- **P** — C, N and S isotopes
- **R** — C_{org}/P_{tot} and C_{org}/N_{org} ratios
- **O** — Trace element geochemistry
- **X** — Sedimentary & petrographic features
- **Y** — Biomarkers

Source Rock Characterization

CASE STUDIES
Marcellus Shale
Appalachian Basin



(Modified from Chen, Sharma et. al., 2015)

Palaeogeography, Palaeoclimatology, Palaeoecology 446 (2016) 85–97

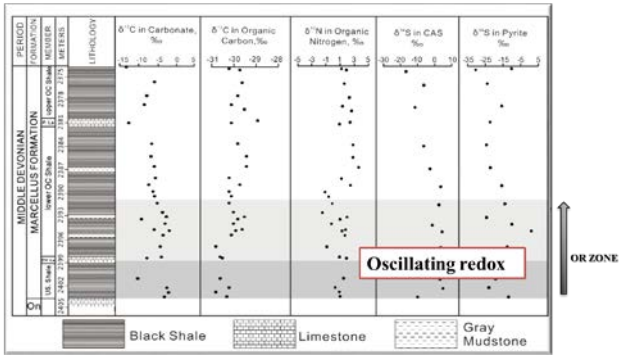
Contents lists available at ScienceDirect

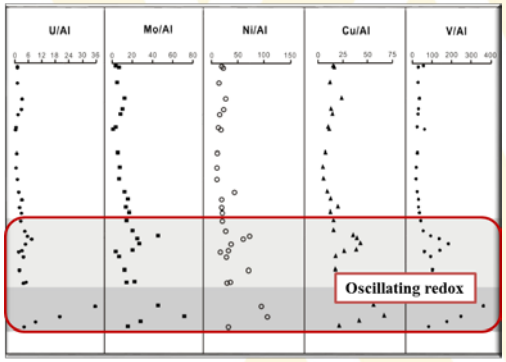
Palaeogeography, Palaeoclimatology, Palaeoecology

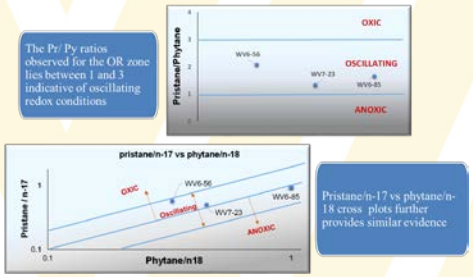
journal homepage: www.elsevier.com/locate/palaeo

Role of alternating redox conditions in the formation of organic-rich interval in the Middle Devonian Marcellus Shale, Appalachian Basin, USA

Ruiqian Chen, Shikha Sharma *,1







Fluctuating N/S isotopic signatures & trace metal ratios in OR zone suggest episodic oxia that might have released & recycled nutrients into water column resulting in elevated primary productivity and higher burial of ORGANIC CARBON

Applied Geochemistry xxx (2015) xxx–xxx

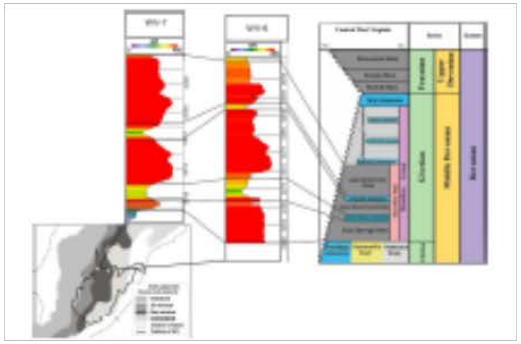
Contents lists available at ScienceDirect

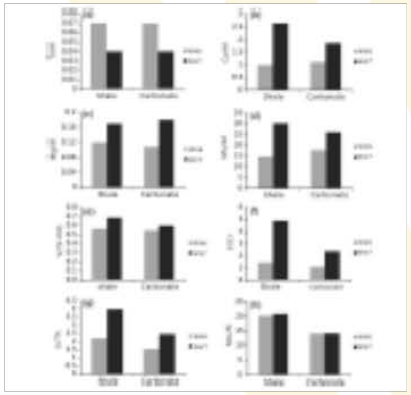
Applied Geochemistry

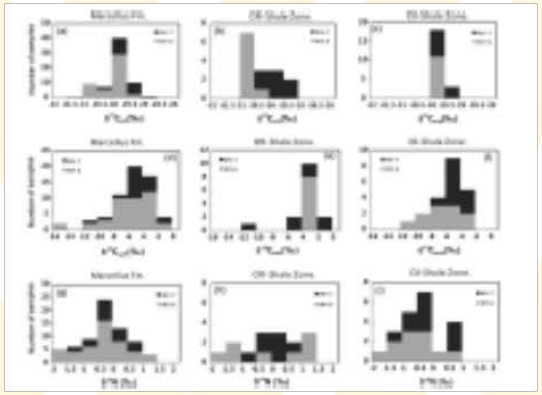
journal homepage: www.elsevier.com/locate/apgeochem

Comparison of isotopic and geochemical characteristics of sediments from a gas- and liquids-prone wells in Marcellus Shale from Appalachian Basin, West Virginia

Ruiqian Chen [a], Shikha Sharma [a,*], Tracy Bank [b], Daniel Soeder [c], Harvey Eastman [d]





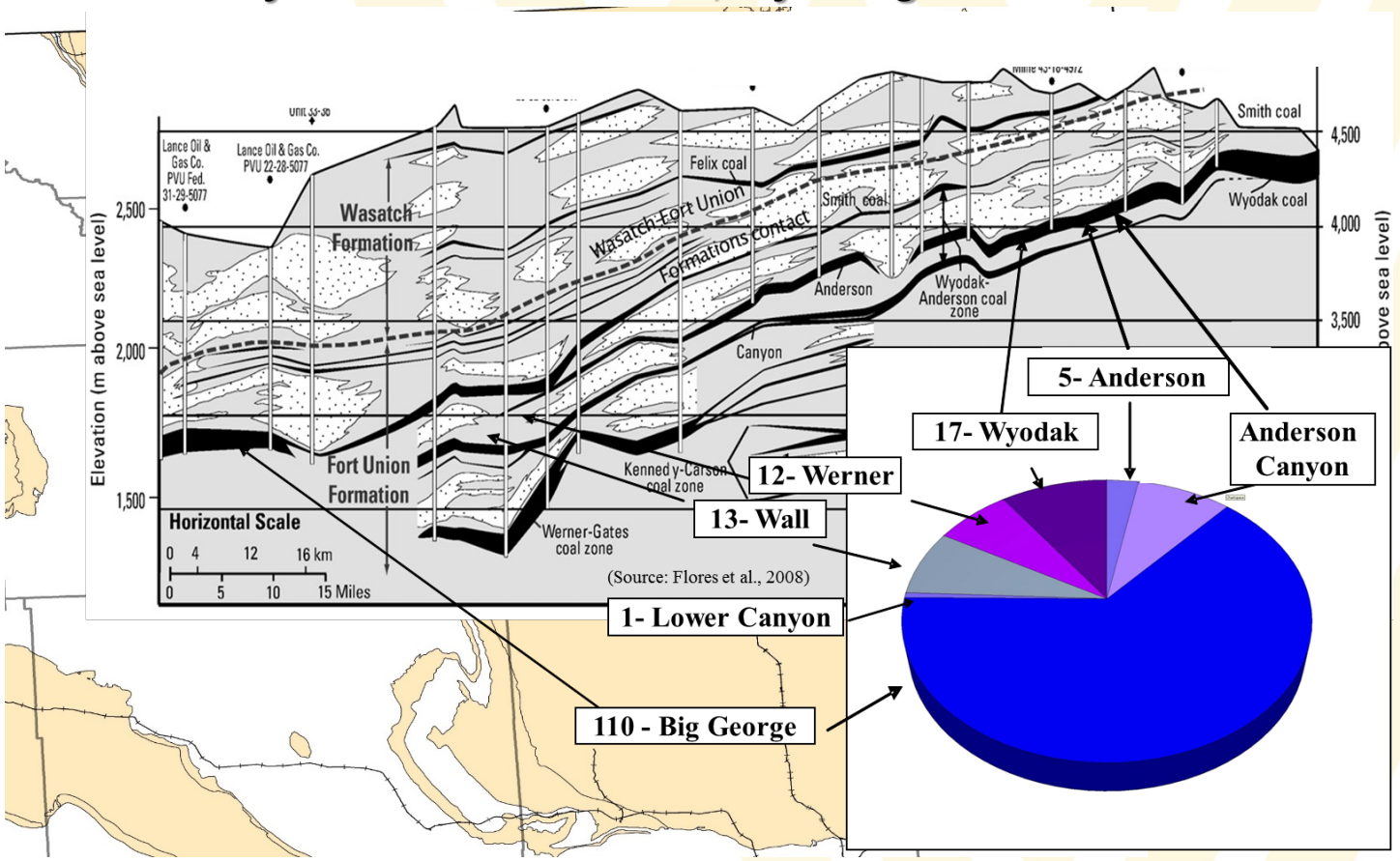


WV-6 core → basin margin → higher influx of clastic sediment & woody, terrestrial OM → generate gas

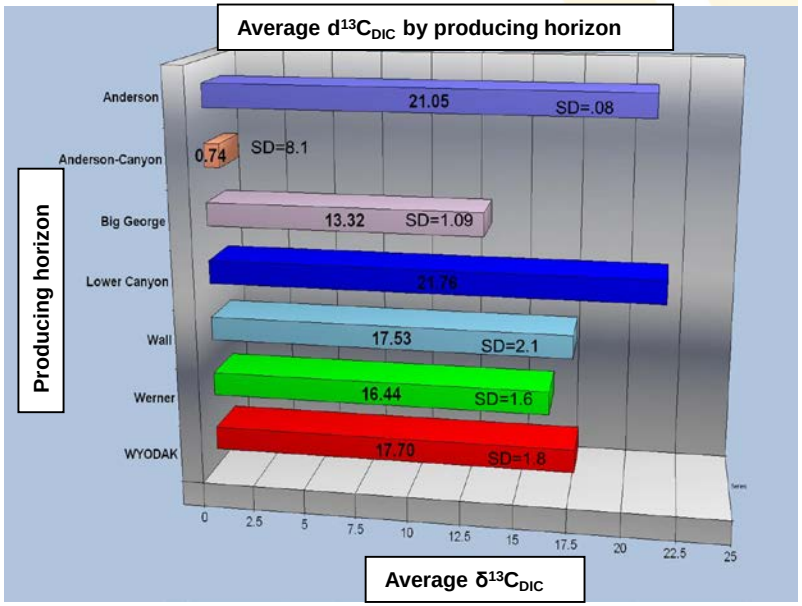
WV-7 core → open marine environment → lipid rich marine OM matter → generate gas & liquids

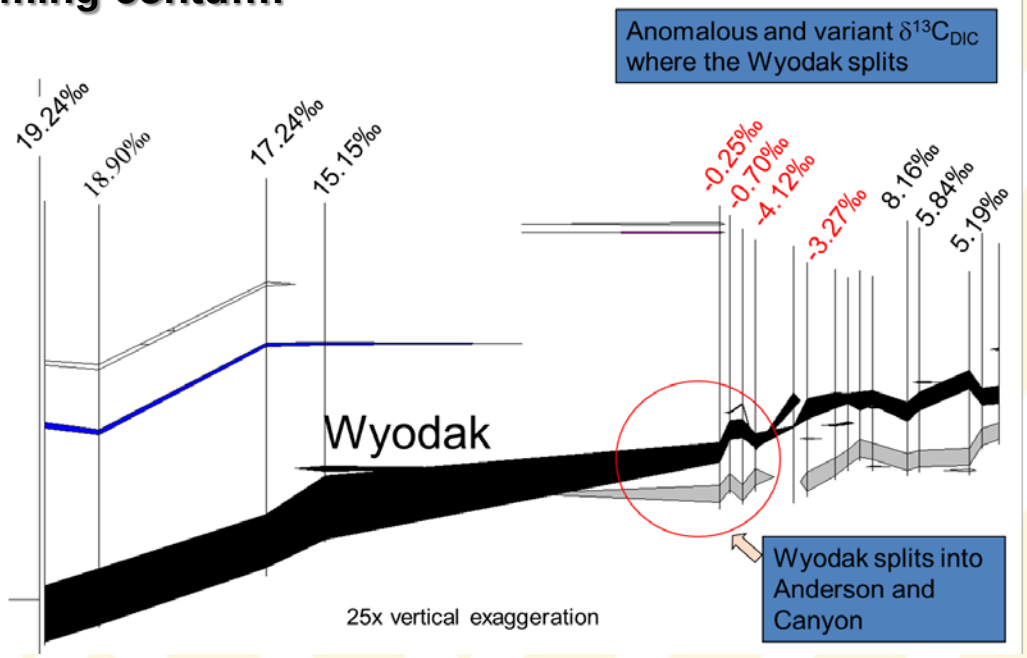
Determining Reservoir Continuity

Case Study : Powder River Basin, Wyoming



Case Study : Powder River Basin, Wyoming contd….

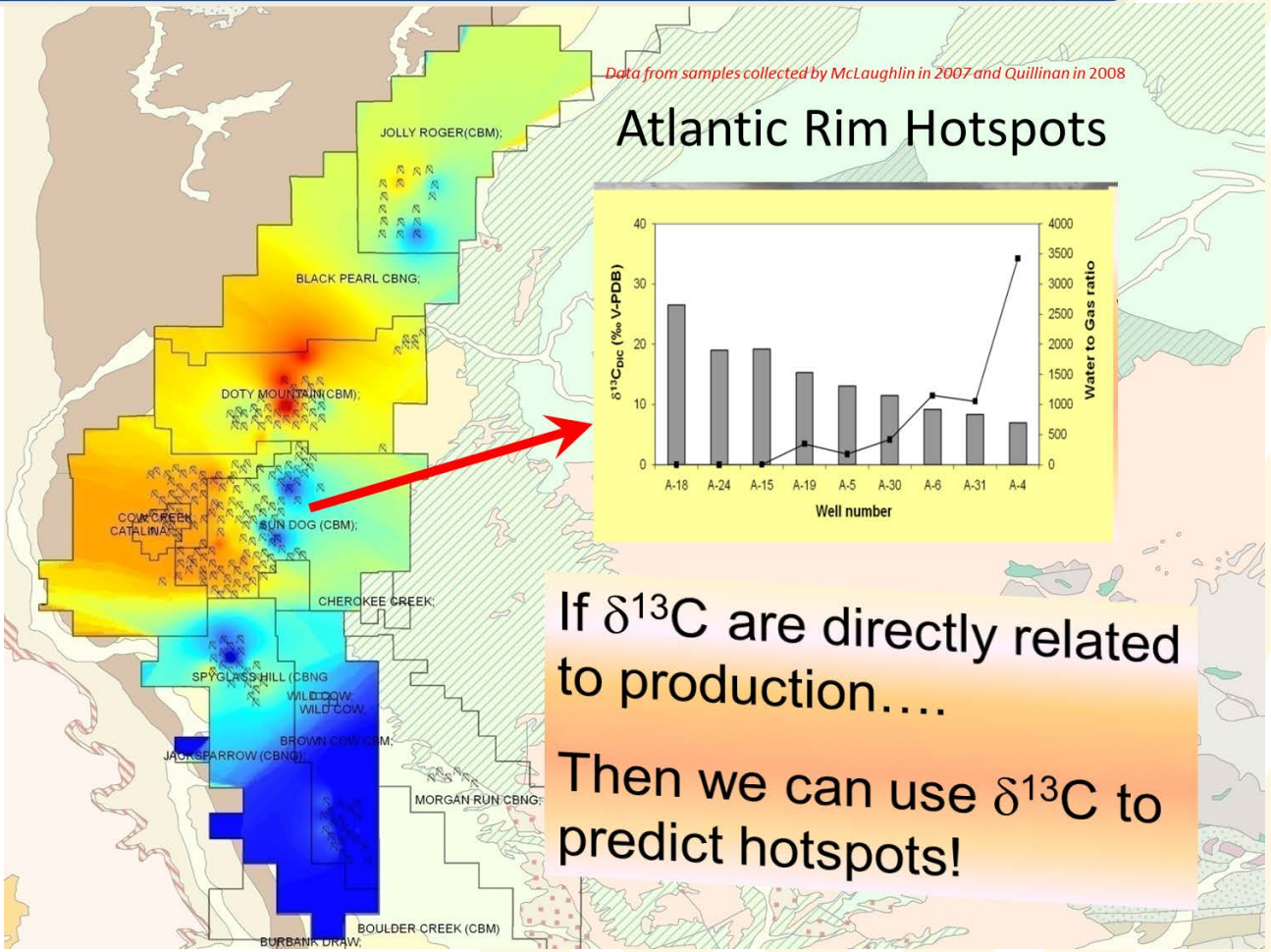




$\delta^{13}C_{DIC}$ of produced water can be used to trace the lateral continuity of individual coalbeds.

Predicting Gas/Water Ratios

Case Study : Atlantic Rim Basin, Wyoming



Shikha Sharma : WVU Geology & Geography

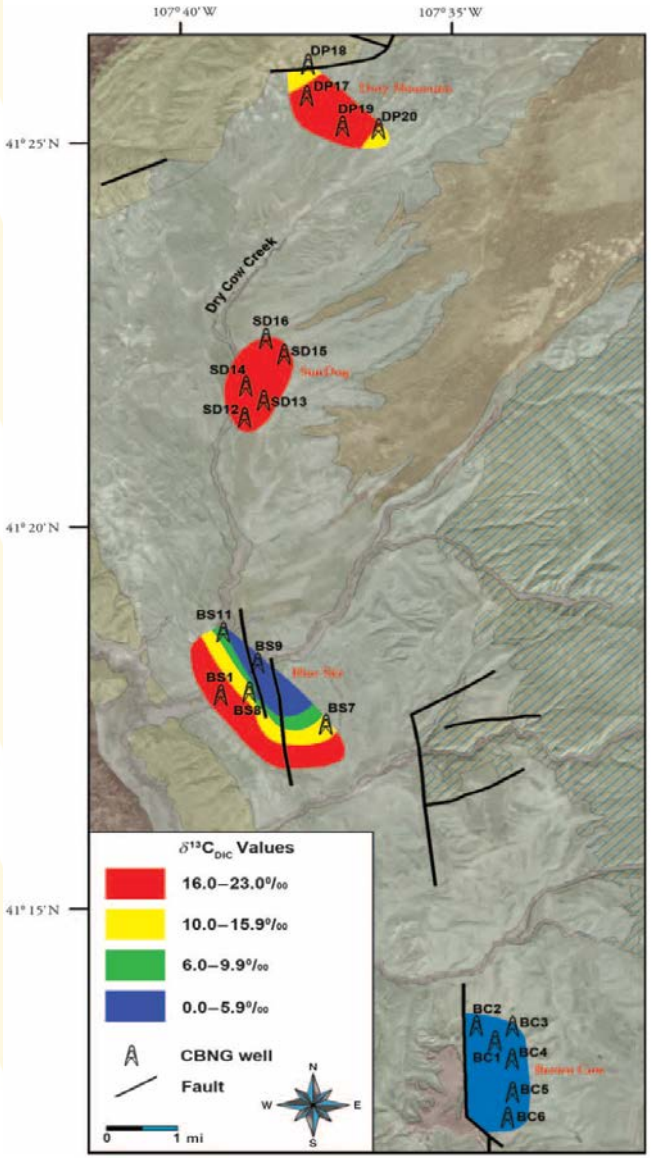
Geochemical analysis of Atlantic Rim water, Carbon County, Wyoming: New applications for characterizing coalbed natural gas reservoirs

J. Fred McLaughlin, Carol D. Frost, and Shikha Sharma

AAPG Bulletin, v. 95, no. 2 (February 2011), pp. 191–217

Lower $\delta^{13}C_{DIC}$ values in produced water indicate:

- Buried faults were conduits of fresh water recharge hence wells had low gas/water ratios
- Wells with poor cement bond logs had low gas/water ratios



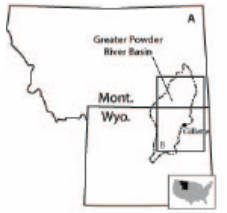
Assessing Environmental Impacts

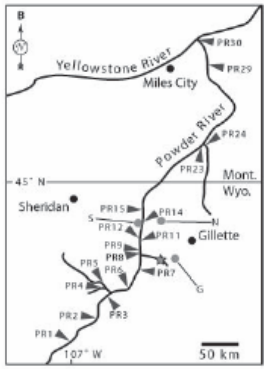
ground water

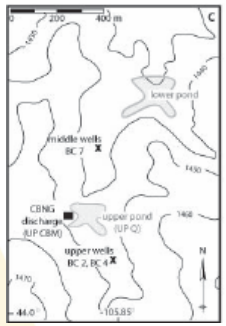
Methods Note/

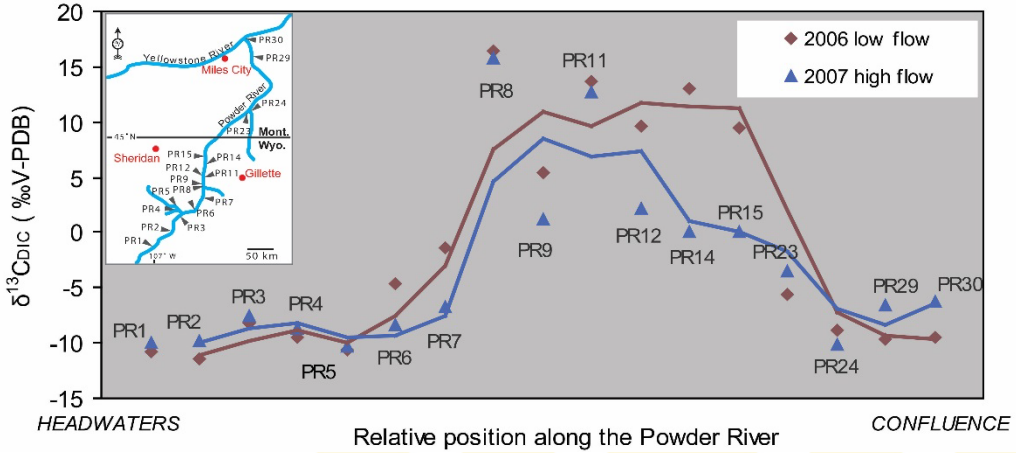
Tracing Coalbed Natural Gas–Coproduced Water Using Stable Isotopes of Carbon

by S. Sharma[1] and C.D. Frost[2]









High carbon isotope signature of CBNG produced water with can be used to trace its input into surface water streams

Assessing Environmental Impacts

PNAS

Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing

Stephen G. Osborn[a], Avner Vengosh[b], Nathaniel R. Warner[b], and Robert B. Jackson[a,b,c,1]

www.pnas.org/cgi/doi/10.1073/pnas.1100682108

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Surface water geochemical and isotopic variations in an area of accelerating Marcellus Shale gas development

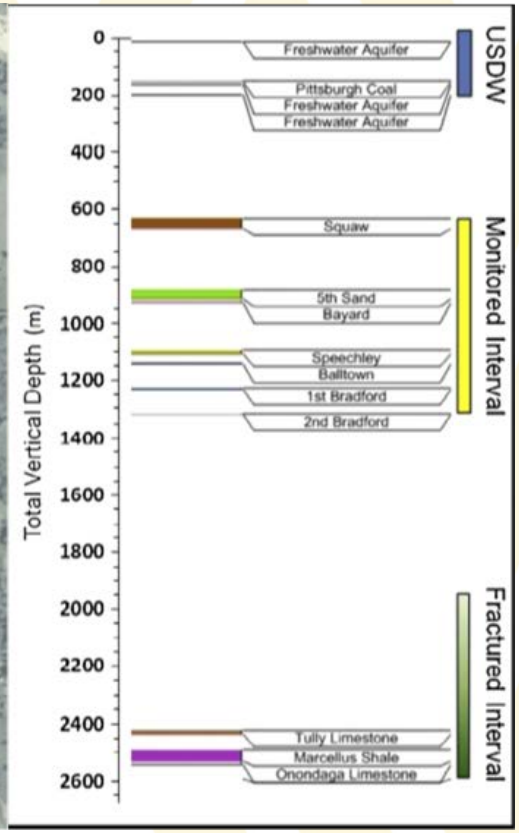
Adam J. Pelak, Shikha Sharma*

Environmental Pollution 195 (2014) 1–10

Contrasting results highlight need for baseline characterization

Determining Zonal Isolation

Case Study : Marcellus Shale Greene County, PA



Presence of overlying producing wells (~4000 ft above Marcellus) which can be used as monitoring wells to test for changes in hydrologic connectivity

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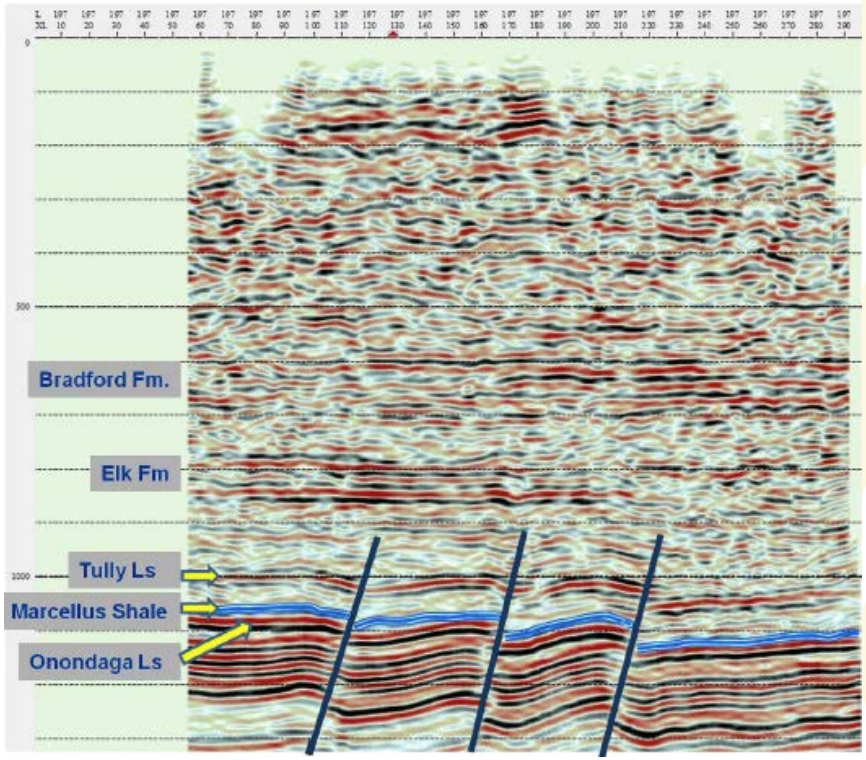
ECA

Determining Zonal Isolation contd…

Case Study : Marcellus Shale Greene County, PA



Multiple Monitoring Tools:

1) 3-D numerical modeling of fracture propagation

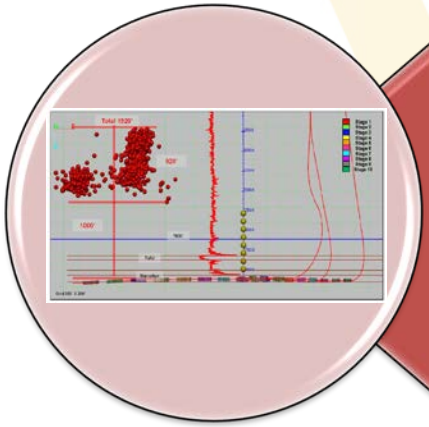
2) Long-term seismic monitoring

3) Artificial PFC tracers

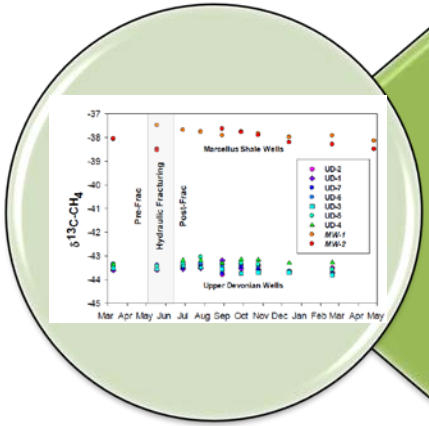
4) Isotope monitoring

Presence of natural faults could augment connectivity

Determining Zonal Isolation contd…

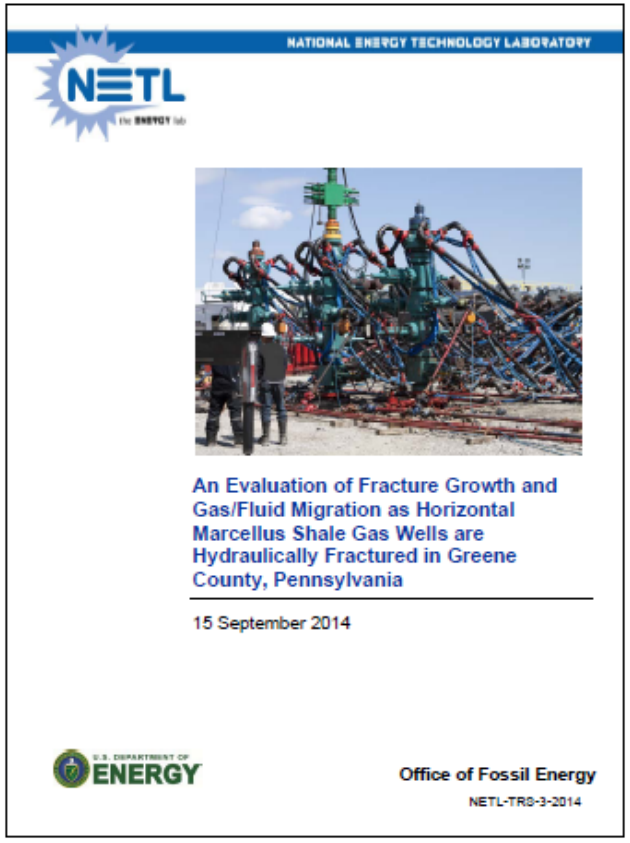


Numerous microseismic events were observed above the Tully Limestone, which is thought to be an upper barrier to fracture growth from hydraulic fracturing in the Marcellus Shale



No evidence of gas or brine migration from the Marcellus Shale to the Upper Devonian/Lower Mississippian gas field during the monitored period after hydraulic fracturing

Determining Zonal Isolation contd…


NATIONAL ENERGY TECHNOLOGY LABORATORY

NETL

An Evaluation of Fracture Growth and Gas/Fluid Migration as Horizontal Marcellus Shale Gas Wells are Hydraulically Fractured in Greene County, Pennsylvania

15 September 2014

U.S. DEPARTMENT OF ENERGY

Office of Fossil Energy

NETL-TRS-3-2014


Contents lists available at ScienceDirect

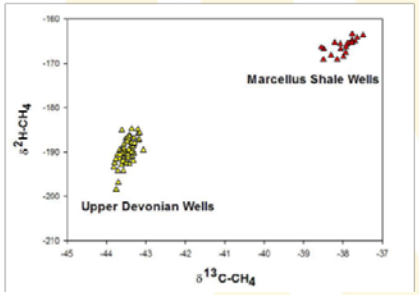
Applied Geochemistry

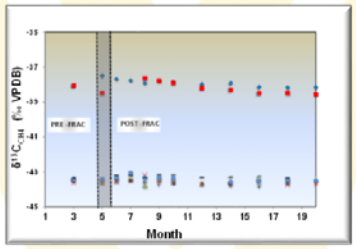
journal homepage: www.elsevier.com/locate/apgeochem

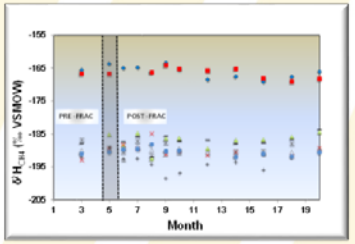
ELSEVIER

Assessing changes in gas migration pathways at a hydraulic fracturing site: Example from Greene County, Pennsylvania, USA

Shikha Sharma [a,b,*], Lindsey Bowman [a,b], Karl Schroeder [c], Richard Hammack [c]





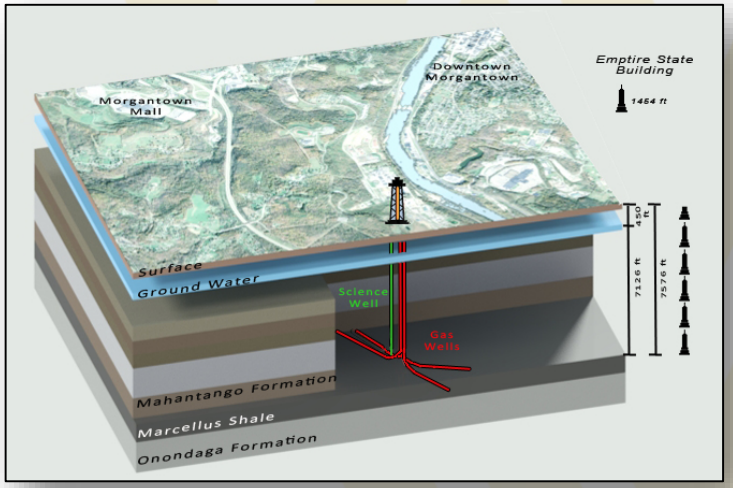


Gas isotopic composition consistent before & after hydraulic fracturing

BIOGEOCHEMICAL STUDIES AT MSEEL

The objective of the Marcellus Shale Energy and Environment Laboratory (MSEEL) is to provide a long-term collaborative field site to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental implications of unconventional resource development

West Virginia University
MSEEL
Marcellus Shale Energy & Environment Laboratory
Northeast Natural Energy



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northeast NATURAL ENERGY
Schlumberger

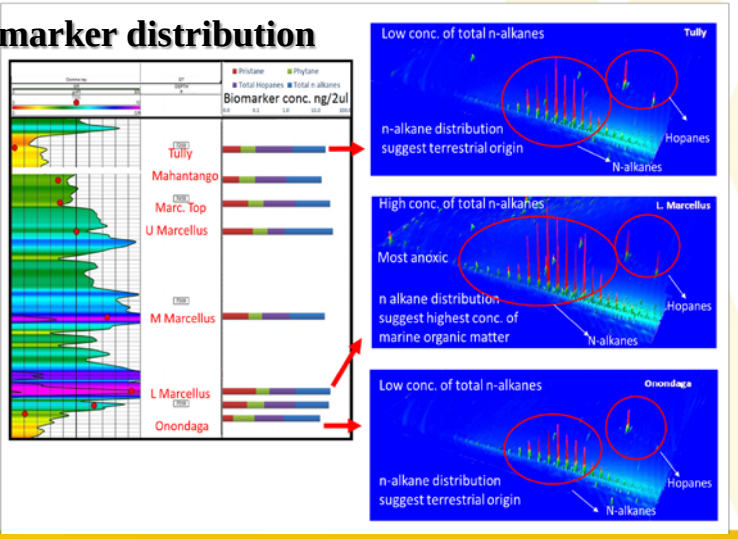
MSEEL Contd……

What are geological controls on microbial distribution, diversity and function ?

- Gas productivity and well infrastructure
- Potential for fracture and pore clogging
- Microbial life/adaptations

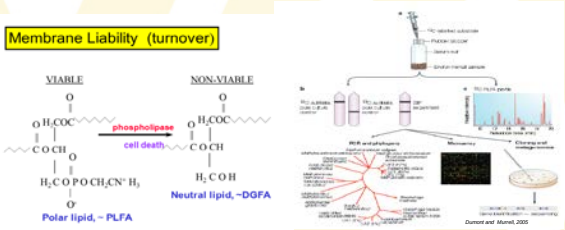
Aliphatic biomarker distribution

Vikas Agrawal
PhD. Student



CSIA & Fatty Acid biomarker distribution

Rawlings Akondi
PhD. Student



S. Pfiffner
UTK

P. Mouser
OSU

- Ratios of physiological stress DGFA/FAME lipid biomarkers
- Changes in the PLFA and DGFA profiles during nutritional & thermal stress
- CSIA will be used to identify microbial populations involved in methanogensis, methanotrophy, sulfate reduction etc.

MSEEL Contd……

What are the plausible fluid-rock-microbe interactions?

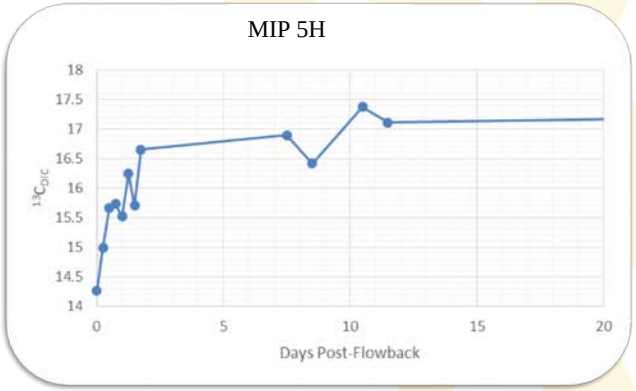
- Evolution of produced water chemistry
- Secondary biogenic methanogenesis
- Well infrastructure & souring

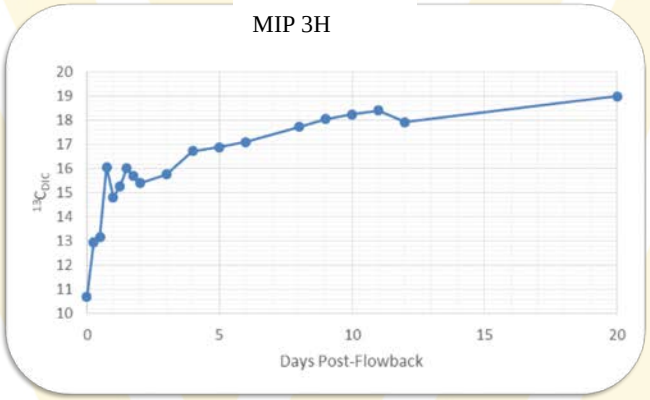
Travis Wilson
MS Student

Collaborators:

NETL — The Ohio State University

Hakala	Mouser, Wrighton
Phan	Wilkins, Cole
Crandall	Darrah





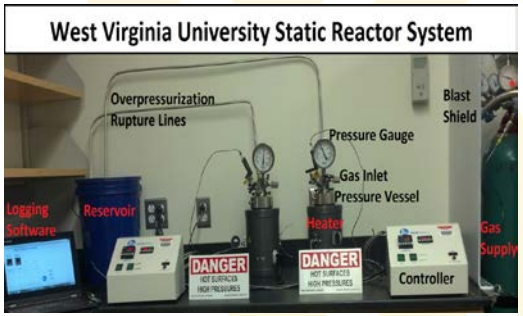
Initial $\delta^{13}C_{DIC}$ enrichment trend in wells 5H and 3H during first few hours to days indicates dissolution of carbonates in reservoir after injection of hydraulic fracturing fluids. High $\delta^{13}C_{DIC}$ values indicate carbonates were precipitated during initial phase of biogenic methanogensis in the reservoir. The C and S isotope trends will be monitored over several months to understand microbial reactions induced in the reservoir after injection of hydraulic fracturing fluids

Decoding Kerogen structure and its interactions

- Changes in kerogen structure and composition on interaction with frac fluids
- Effect of changes in kerogen on chemistry and flow of produced water and gases

Vikas Agrawal
PhD. Student

Behar & Vandenbroucke, 1987



Collaborators:

Pacific Northwest NATIONAL LABORATORY

Hoyt, Walter, Malak