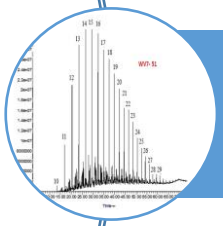
SHARMA ISOTOPE LAB

High Resolution Characterization of MSEEL Core

High resolution multi sensor logging/imaging and SRA analysis

Collaborators: Crandall and Soeder @ NETL



Isotopic/molecular/microbial characterization of core

Collaborators: Mouser, Wrighton, Wilkins, Cole @OSU

Modelling fluid-rock interactions from lab to field scale

Collaborators: Crandall, Hakala, Lopano @ NETL

SHARMA ISOTOPE LAB

What we propose to measure:

- Total Organic Carbon and Nitrogen
- Carbon isotope of organic carbon ($\delta^{13}C_{org}$)
- Carbon and oxygen isotopes of carbonate carbon ($\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$)
- Nitrogen isotope composition ($\delta^{15}N$)
- Sulphur isotope composition ($\delta^{34}S$)
- Molecular Biomarkers: n-alkanes, pristanes, phytanes, hopanes, steranes etc.
- Elemental Geochemistry

SHARMA ISOTOPE LAB

Research questions we seek to answer:

What is the spatiotemporal variations in elemental and isotopic composition?

- Natural/induced fracture networks
- Implications for rock-fluid interactions

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

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

What are major controls on source/type of organic matter?

- Oil vs gas production
- Frackability/Re-stimulation
- Porosity and permeability effects

What are plausible fluid-rock interactions?

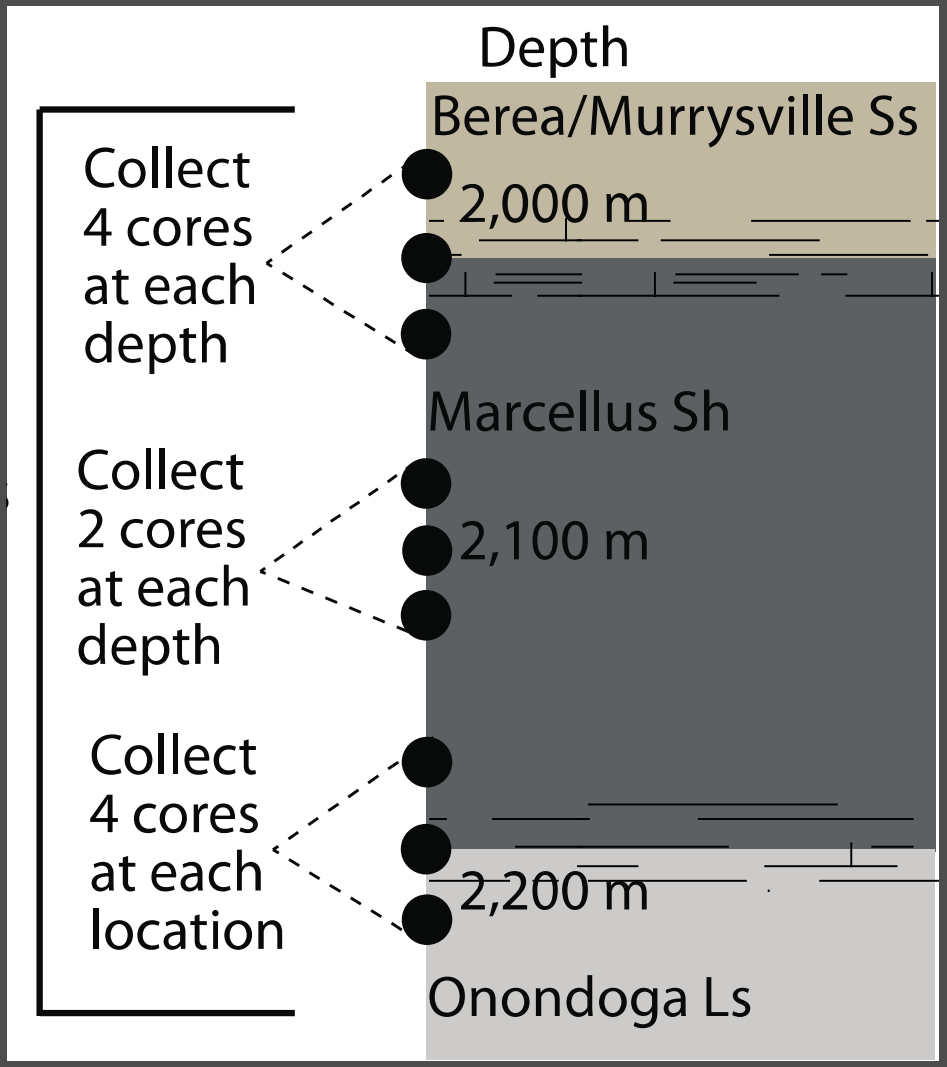
- Evolution of produced water chemistry
- Mechanism of water exchange
- Implications on well infrastructure & souring

SHARMA ISOTOPE LAB

Our Sample Requirement:

- 5g of sample from the inner part of the vertical core; sampling interval TBD based on MSCL (multisensor core logger) data
- 10 sub-cores (1.5*4 inch diameter) from vertical core; sampling interval TBD based on MSCL and isotope data
- Drill cuttings from horizontal well
- Sidewall cores to be coordinated with OSU microbiology group

Sidewall Core: OSU-WVU Biogeochemical Analysis



Objectives:

1. To determine extent of life in shale
2. To examine how diversity and function relates to geology, mineralogy, geochemistry, & hydrocarbon production

Targeting 9 locations

- Formation Interfaces
- High TOC zones
- Fracture zones

Will collect 2-4 sidewall cores/depth

Targeted locations based on:

- Previous and current geophysical logs
- Other measurements (e.g. TOC)

Sampling Constraints

1. Low microbial biomass is expected in the shale and will be difficult to distinguish from high biomass signals in drilling fluids.

2. We therefore need to minimize the introduction of muds and fluids that contain non-indigenous cells.

3. We need to identify potential surface microbial contamination to provide evidence of sample purity via tracers

Sidewall Core Sampling Procedure

Objectives:

1. To identify core sections which have come in contact with coring fluids

2. To provide a visual confirmation that introduced microbial contaminants have been removed before processing

Procedure:

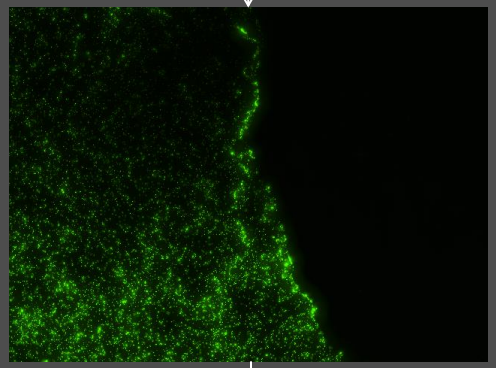
1. Add fluorescent microspheres (0.5 μm diam) to coring fluids at target concentration via injection line pump or tank. Alternatively use break-bag technique in core catcher

2. Examine microscopically (441 nm excitation, 486 nm emission)

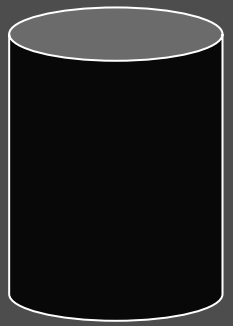
3. Hand pare contaminated sections before processing

4. Retain pared sections for background controls

Fluorescent Microspheres in concentrated and dilute form



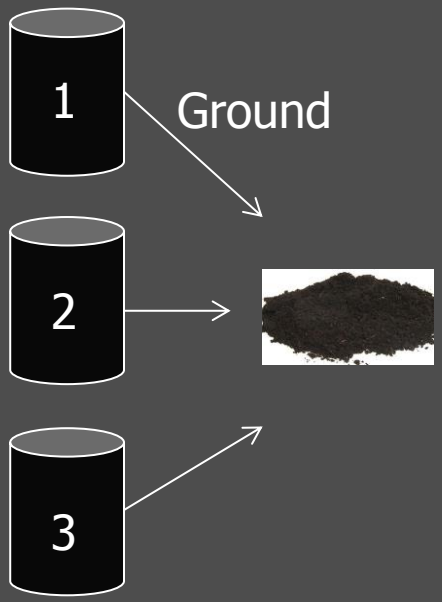
Microscopic image showing ½ core section applied with spheres (left) and ½ core clean (right)



Intact sidewall core pared for processing

Sidewall Core Processing

At Each Transect



Planned Analyses:

Mouser (OSU): Biomass estimates and microbial lipid analysis

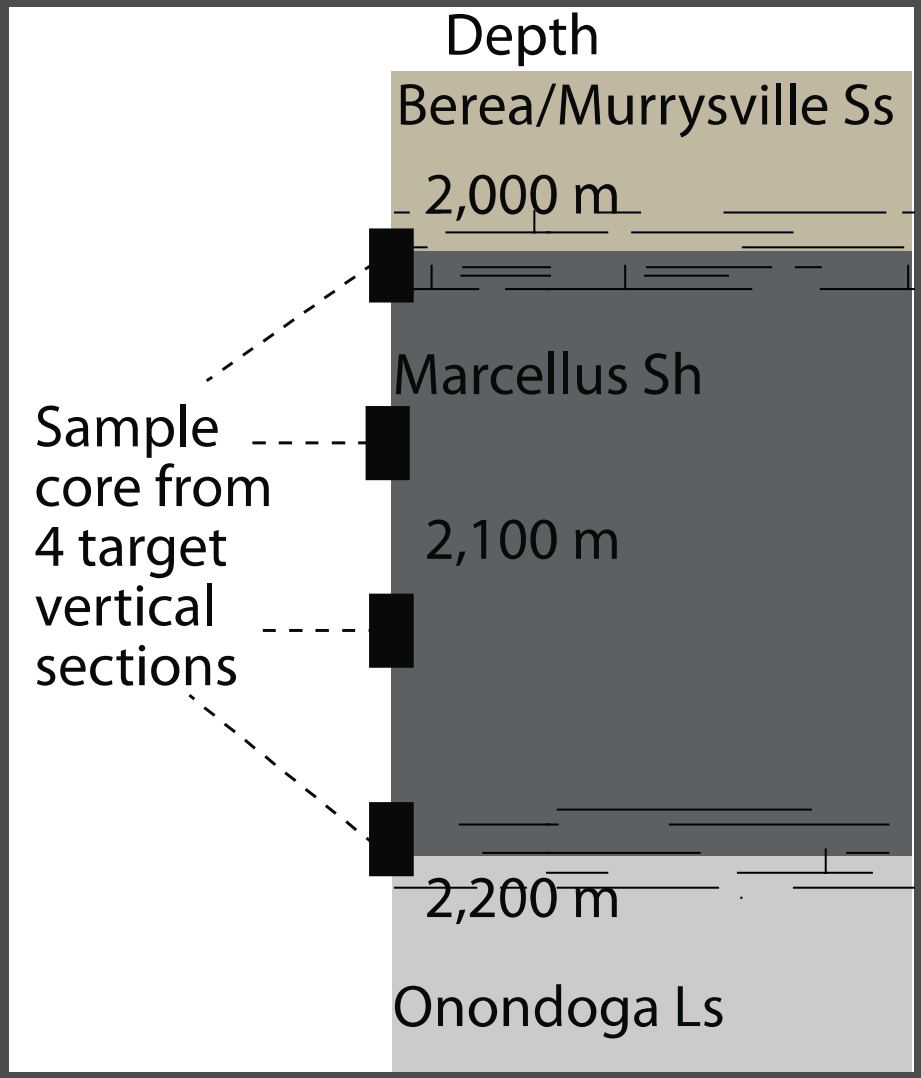
Wrighton (OSU): Metagenomic analysis

Sharma (WVU): Biomarker-specific isotope analysis

Wilkins (OSU): high pressure/temperature isolations and enrichments of indigenous microbes

Cole (OSU): pore structure, porosity, mineralogy, and geochemical analysis.

Vertical Core: OSU-WVU Biogeochemical Analysis



Objectives:

Same as sidewall, but with larger intact core sections after visual inspection.

Targeting 4 locations

- Formation Interfaces
- High TOC zones
- Fracture zones

Samples will be for similar analyses shown in the sidewall core.

Outstanding Questions

1. Can one sidewall run be dedicated to this sampling?

2. Can we see/inspect/swab the equipment that will be used for sidewall coring?

3. What sort of pump apparatus do we need to apply tracer curing sidewall coring? What volumes will be used? Can we use tracers in plastic bag that breaks upon core sampling?

4. Can a tracer also be used for vertical coring?

5. Can vertical core sections be collected before cores are sent to core lab for processing?