

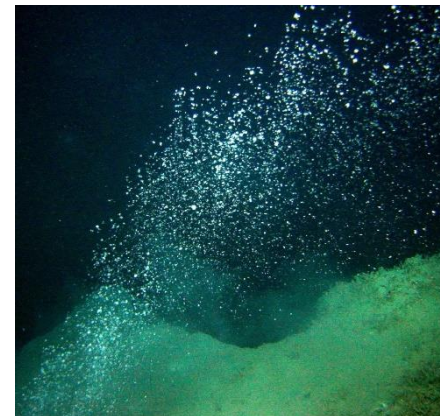
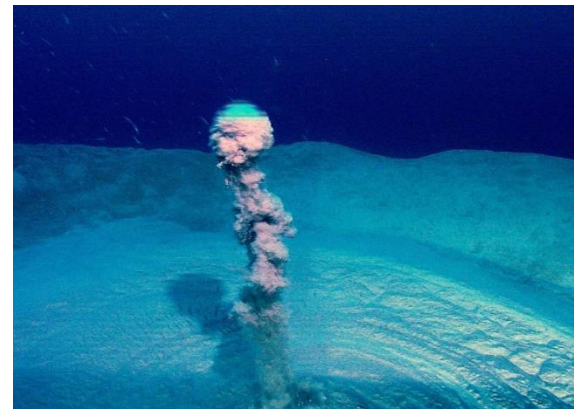
# Advancements and Learning in Hydrocarbon Seep Hunting as a Critical Tool for Early-Stage Oil and Gas Exploration

Bryan Bergkamp

AOG 2019

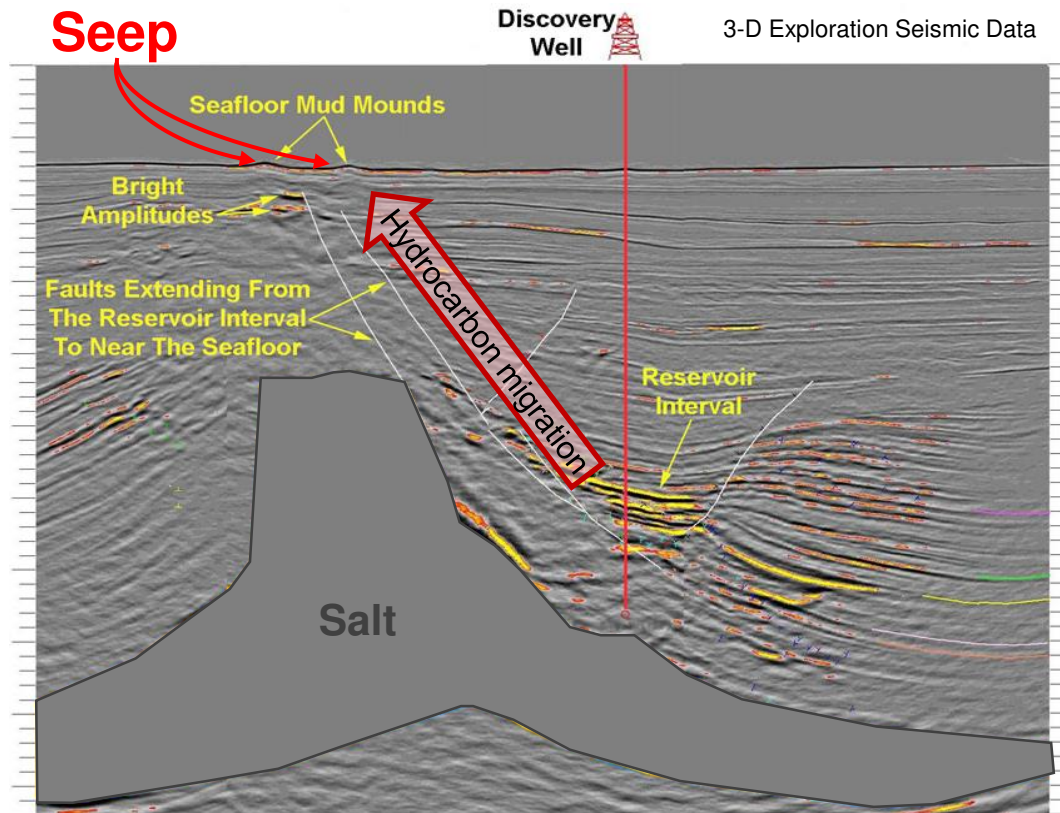
# Summary

- What is a seep?
- Seep hunting
  - An iterative process of collecting and interpreting geophysical data to identify the best sites for geochemical sampling
    - Seafloor mapping and target selection
    - Seafloor sampling
    - Shipboard geochemistry
- Benefits of shipboard geochemical analysis
- Comparison of shipboard and shore based headspace gas chromatography analysis



# Introduction to Seeps

- Faults extend from the reservoir interval to near the seafloor
- Shallow amplitude anomalies and seafloor mud mounding suggest the potential for hydrocarbon seepage
- Hydrocarbon signal at the seafloor can give information about the reservoir **before exploration drilling**
  - Thermogenic vs. biogenic gas
  - Reduced drilling risk



# Seep Hunting Overview



Survey Planning

Offshore Seep Hunt

Advanced Geochemical  
Laboratory

Frontier Areas

Exploration  
2D and 3D  
Seismic Data

Seafloor Mapping

Multibeam Echo Sounder Data

- Bathymetry
- Backscatter
- Water Column

Seafloor Sampling

- Piston Core
- ROV

Third Party  
Shore Based  
Geochemistry  
Laboratory

Advanced Screening

Shipboard Geochemistry: Standard Screening

- Headspace Gas Chromatography C1-C5
- Total Scanning Fluorimetry (TSF)

Integrated Data  
Deliverable & Report

Heat flow, metocean, environmental baseline, towed camera

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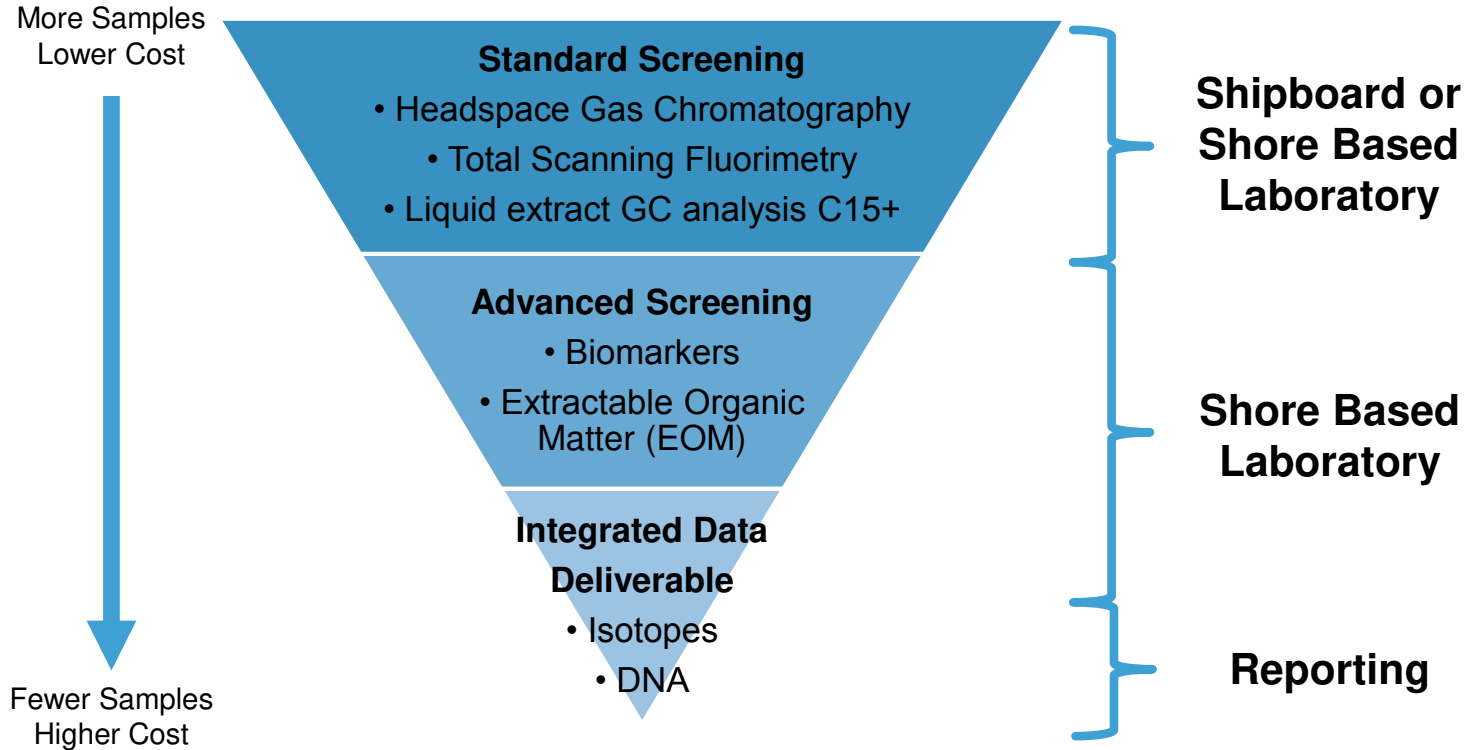
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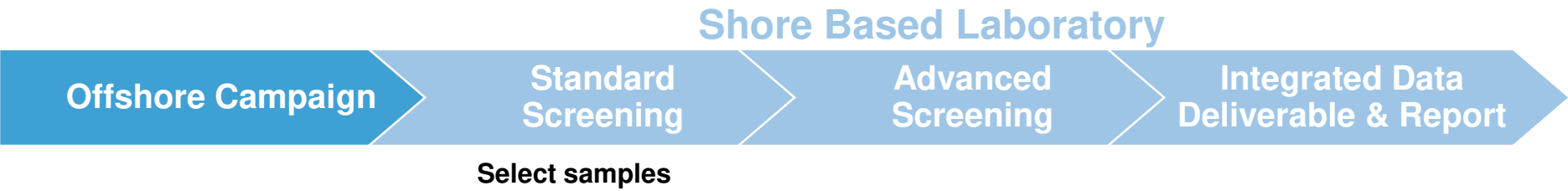
# Simplified Geochemical Analysis Progression





# Schedule Comparison

## Without Shipboard Geochemistry



## With Shipboard Geochemistry



# Survey Vessel Selection

- Hull-mounted multibeam echo sounder
- Sub-bottom profiler
- A-frame for piston coring
- Deck space for geochemical sampling laboratory containers or internal lab space





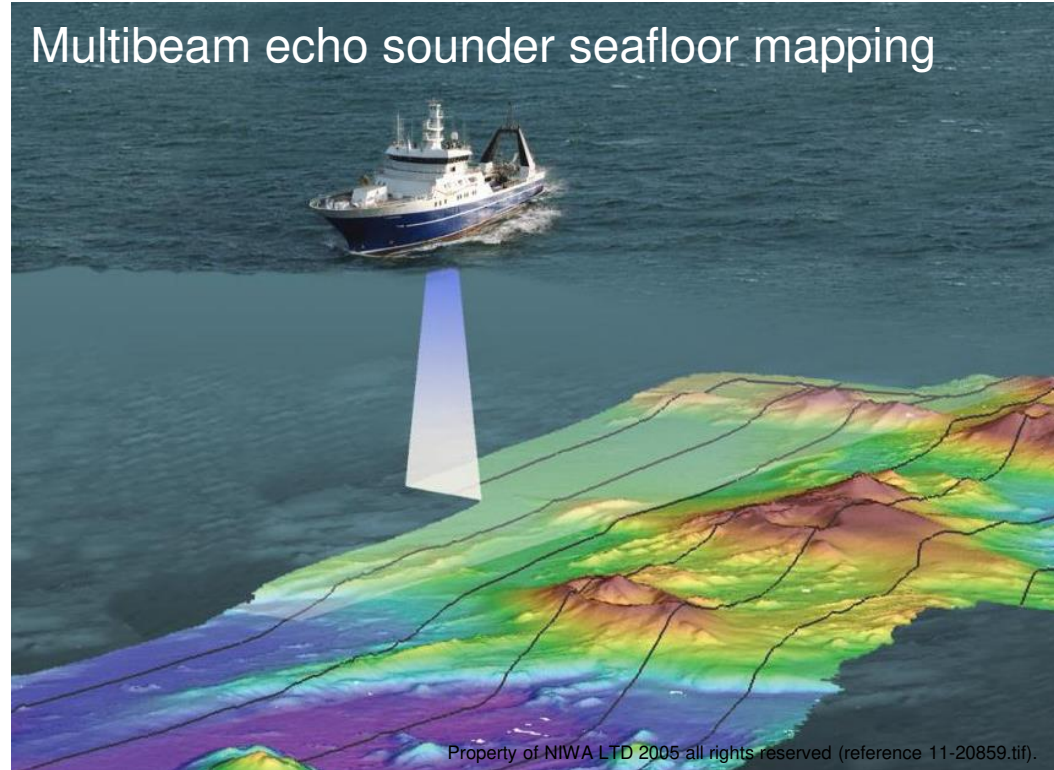
# Seafloor Mapping

Before the wide use of seafloor imaging, offshore seep hunting in frontier areas was performed by acquiring seafloor samples in a regularly spaced grid.

Point-source hydrocarbon seeps may be missed by grid sampling.

High-quality multibeam echo sounder seafloor mapping is used to “hunt” for seeps so they can be accurately sampled.

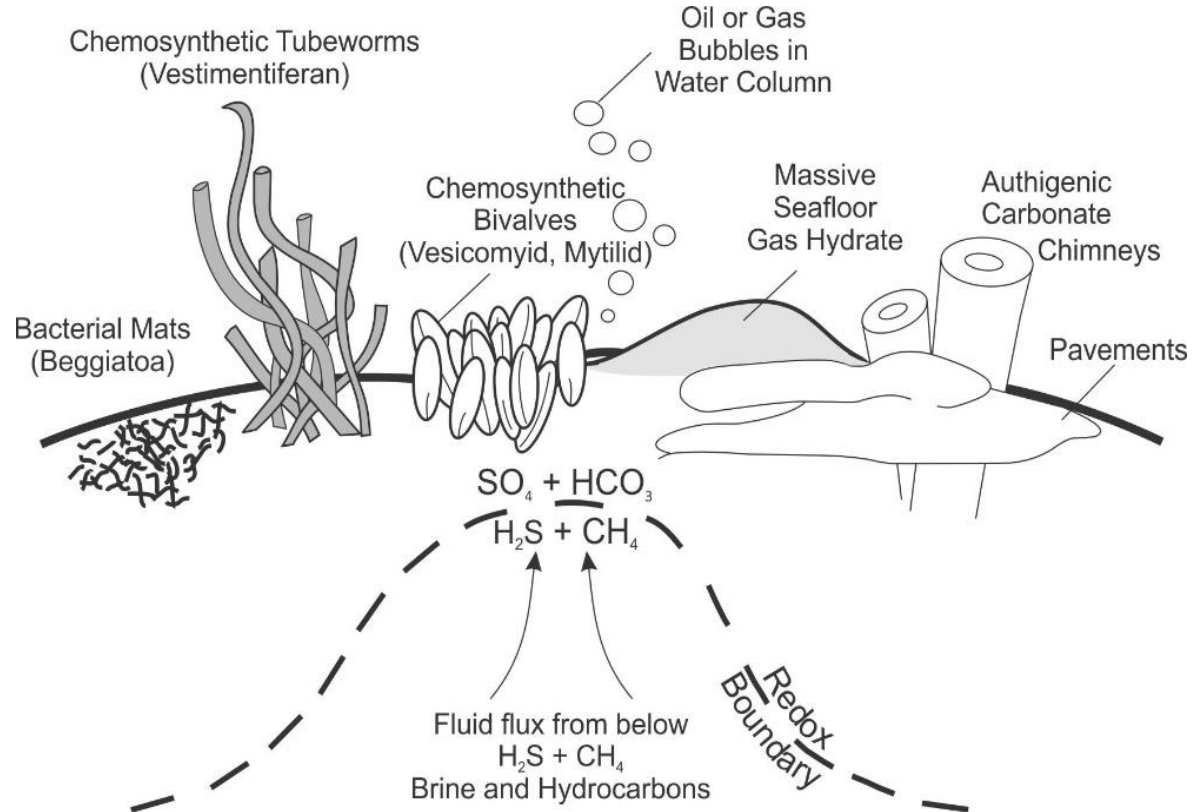
## Multibeam echo sounder seafloor mapping



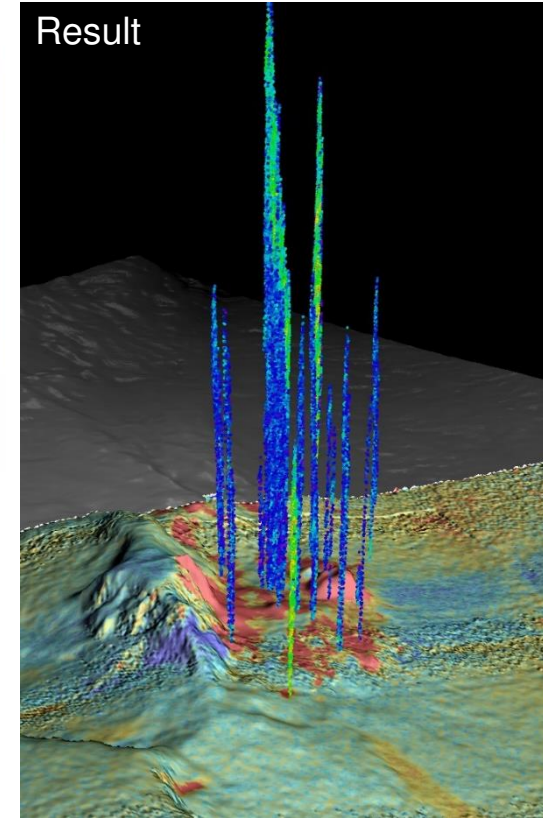
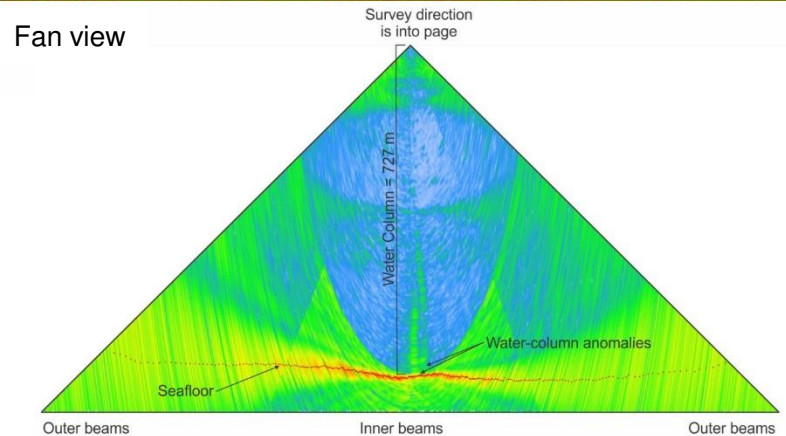
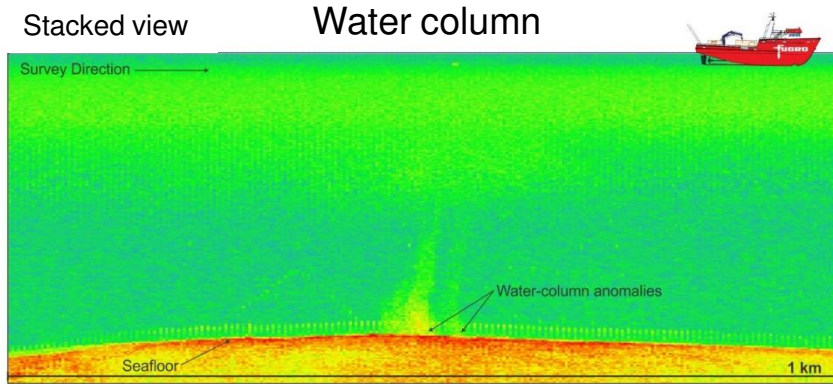
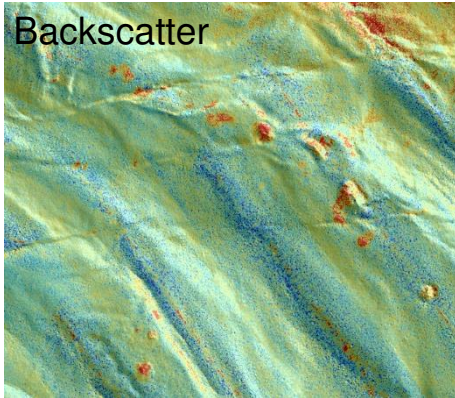
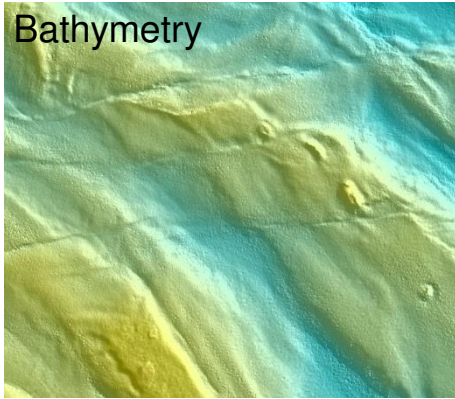
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# Anatomy of a Hydrocarbon Seep

- Quality seeps yielding positive geochemical signals are focused point sources on the seabed
- Upwelling fluids, react with shallow pore fluids to create carbonate nodules, chimneys, slabs, and mounds at and below the seafloor
- Chemosynthetic organism communities use seeping hydrocarbons as energy
- Seepage velocities ranged 3 cm/yr. at the seep to 0.2 cm/yr. at 80 m from the seep
- Missing the target by tens of meters can yield inconclusive geochemical signal

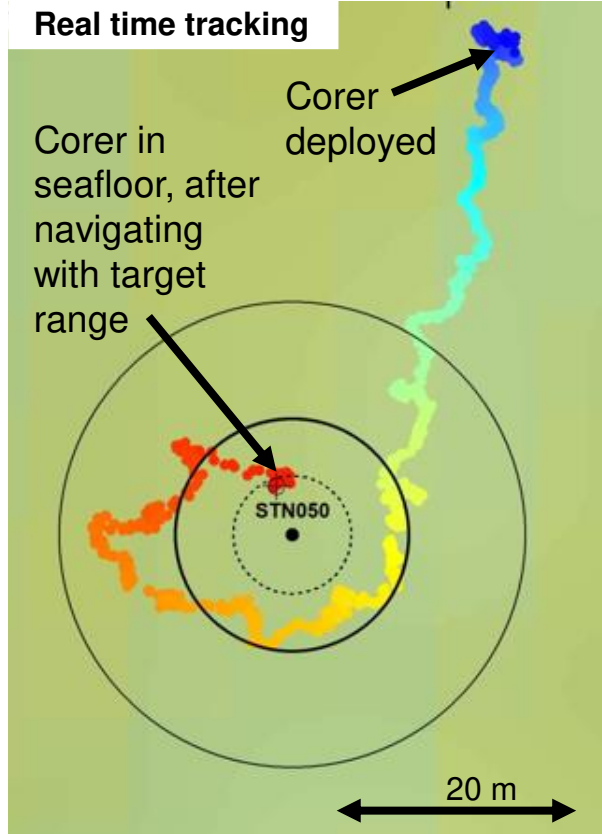


# Multibeam Echo Sounder Seep Hunting





# Seafloor Sampling using Six-Meter Piston Core

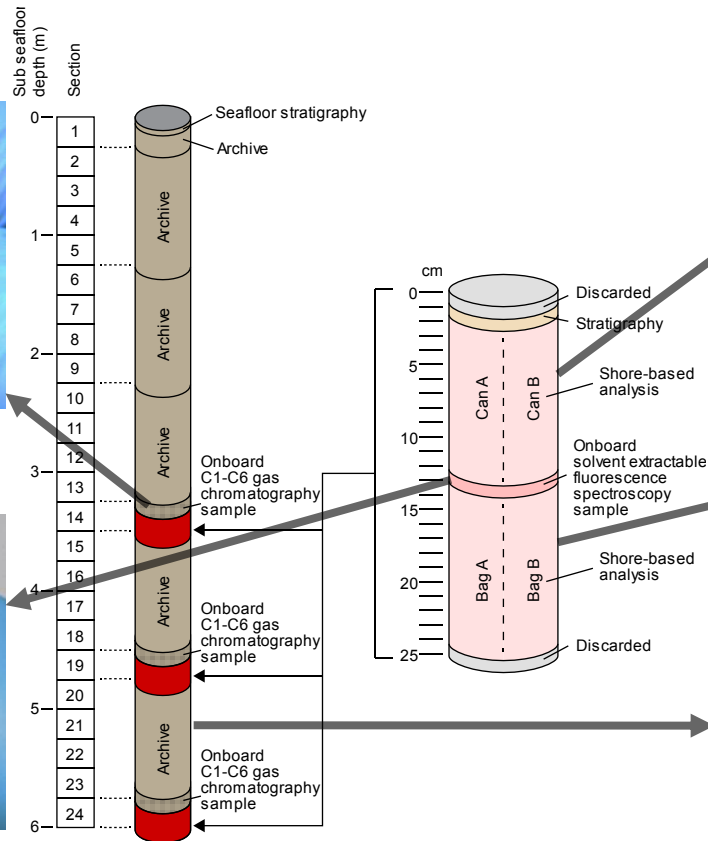


# Geochemical Sub-Sampling

## Headspace Gas



## Fluorimetry



## Samples for Shore Based Analysis



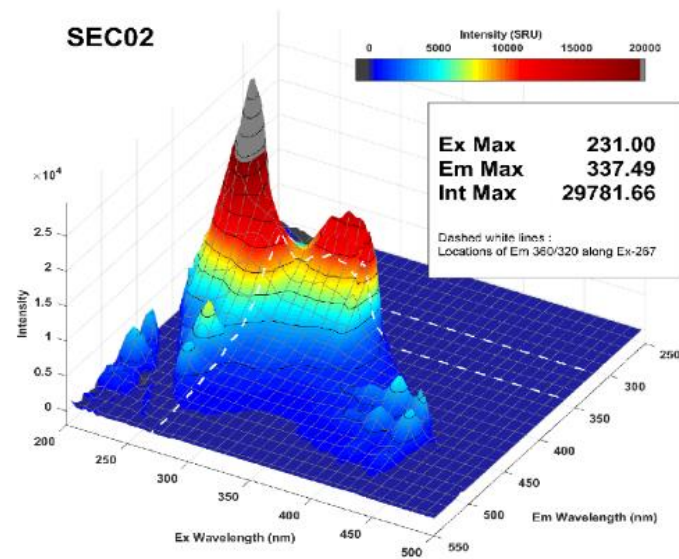
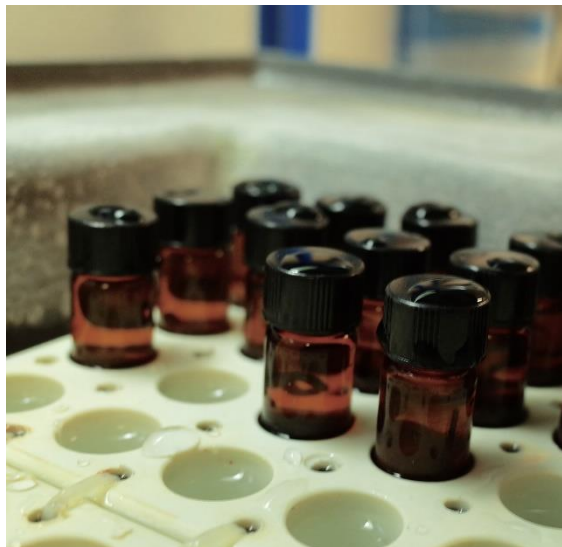
## Archives





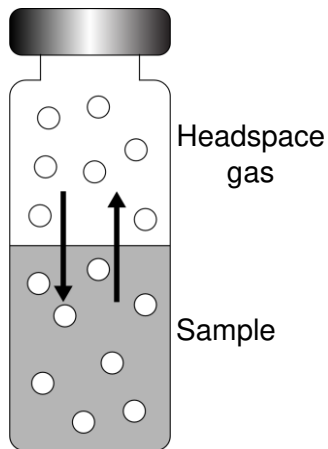
# Shipboard Geochemical Analysis Total Scanning Fluorimetry

- Shipboard geochemistry has wider use in academia, but limited commercial use
- Total scanning fluorimetry results are ready within 48 hours of sample acquisition
- Shipboard TSF results qualitatively correlate with shore based TSF results



# Shipboard Geochemical Analysis Gas Chromatography

- Headspace gas chromatography results are ready within hours of sample acquisition
- Identifies samples with potential for thermogenic gas indicators (contain high proportion of C<sub>2</sub>+, propane, butane, etc.)



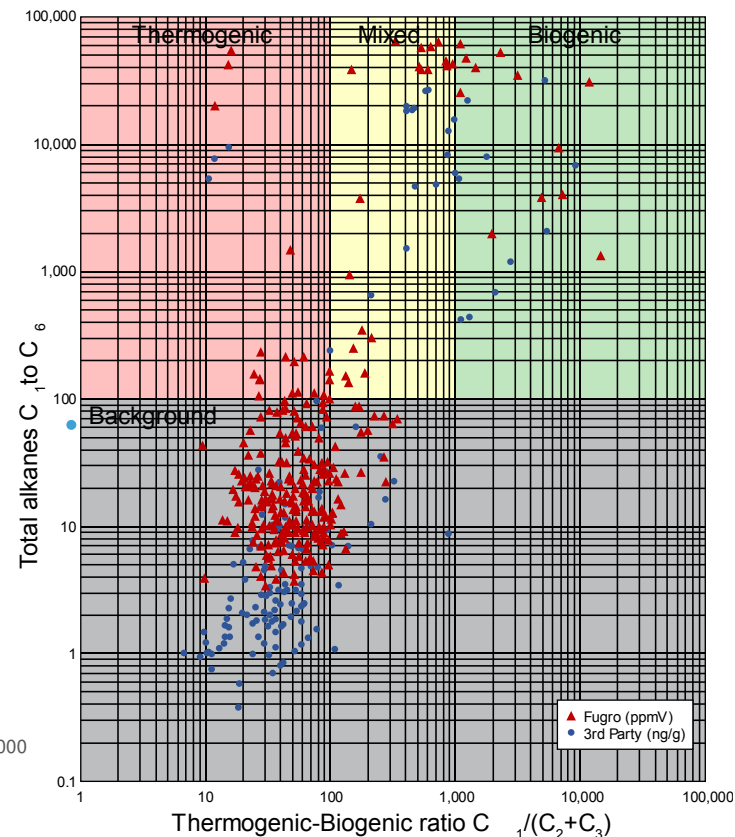
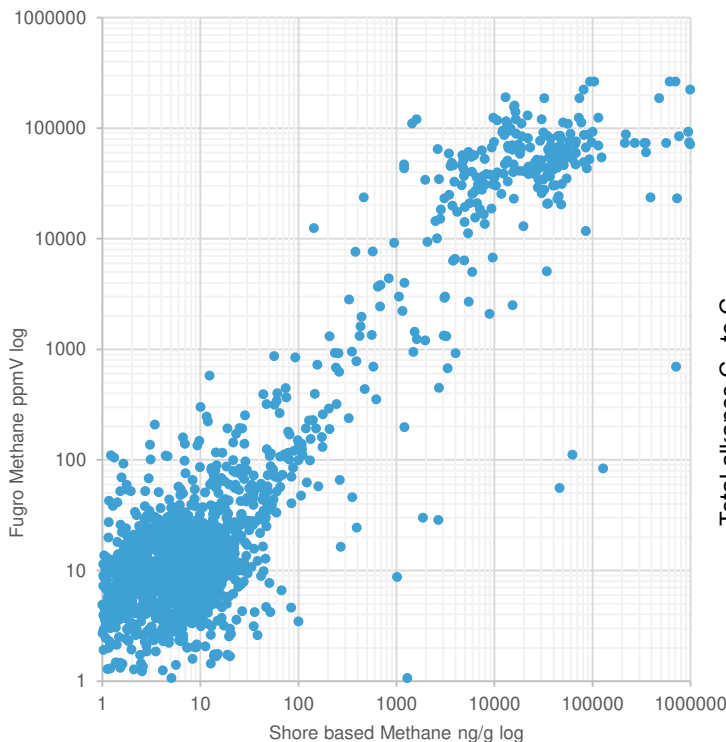
Headspace gas is the gas above the sample. It contains volatile organic components released from the sample.

These components are analyzed with gas chromatography.



# Headspace Gas Concentration Correlation

- 2,000 samples analyzed and compared
  - Fugro shipboard laboratory
  - Four shore based laboratories
- In general samples compare very well
- For samples near background level, shore based laboratory analysis generally yielded lower headspace gas concentrations as compared to shipboard analysis



# Summary of Shipboard Geochemical Analysis

- Geochemical results are used in the field to guide the seafloor sampling program
  - Headspace gas chromatography results ready within hours
  - Total scanning fluorimetry results ready within 48 hours
- Identify samples in the field with potential for thermogenic gas indicators (thermogenic vs biogenic source)
- Analyses are performed for all samples giving a complete standard screening dataset
- Reduced time of shore based laboratory program
- Less risk of sample degradation during transit to shore based laboratory
- Optimize time and cost of program

Thank you

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