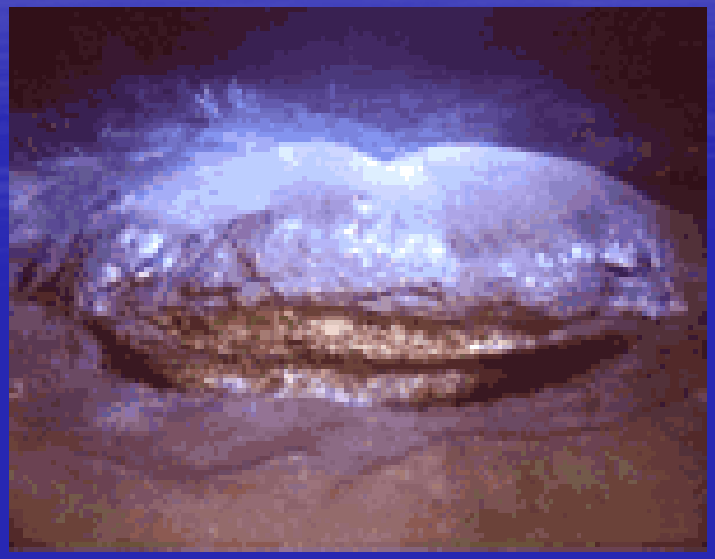
A SEA FLOOR OBSERVATORY FOR REAL-TIME INVESTIGATION OF GAS HYDRATES

J. Robert Woolsey and Carol B. Lutken

Center for Marine Resources and Environmental Technology

The University of Mississippi

NATURAL GAS HYDRATES



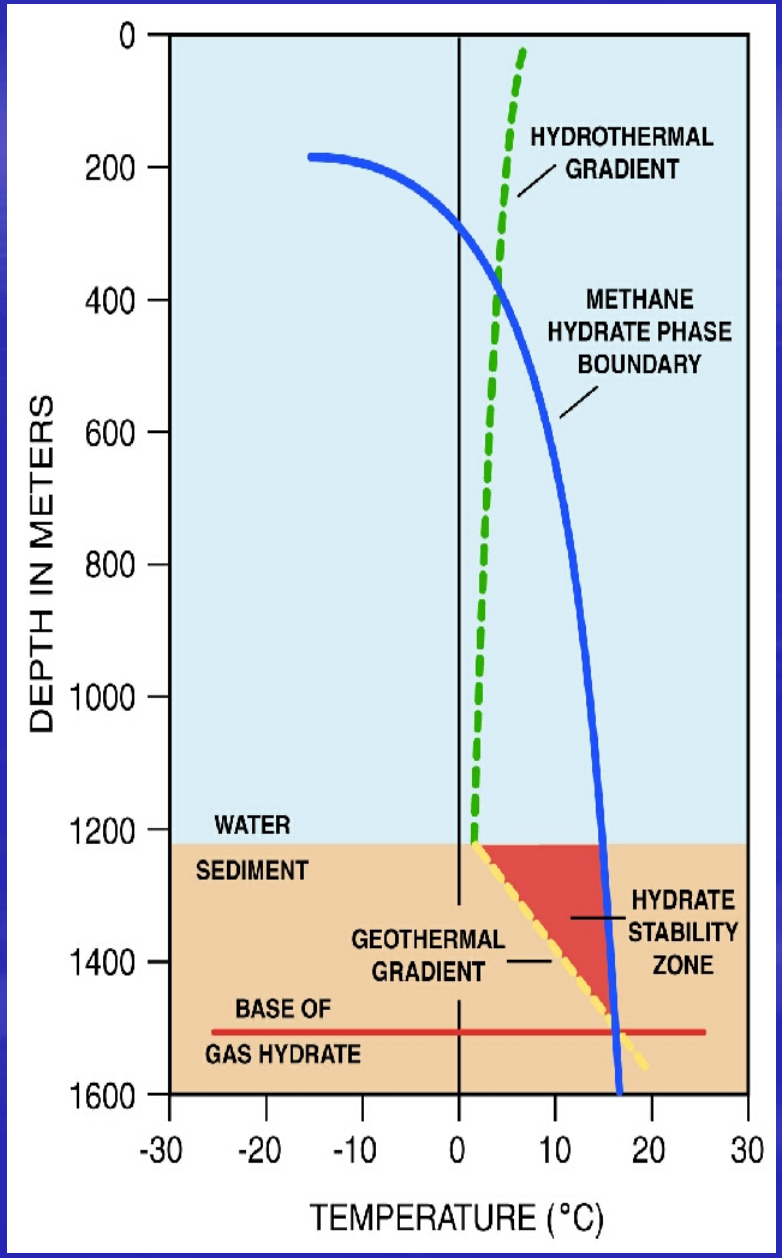
crystalline minerals composed of water and naturally-occurring gases such as hydrocarbons, carbon dioxide, and hydrogen sulfide

form within definite ranges of temperature and pressure (T-P) that comprise the Hydrate Stability Zone

NATURAL GAS HYDRATES …

form when favorable T's and P's coincide with the availability of water and suitable gases

are believed to be relatively "short-lived" deposits, their association/dissociation controlled, at least in part, by geologically-derived alterations of T and/or P and producing features such as pockmarks and mud volcanoes, mud diapirs and fluid expulsion features.



Gas Hydrates

- Abundant
- Relatively inaccessible
- Transient, susceptible to change

Conventional studies of marine gas hydrates have relied on periodic visits by research vessels. These have proven inadequate to understand the changes and what causes them.

Gulf of Mexico
Hydrates Research Consortium

Purposes:

Consolidate research efforts

Afford continuous observation

Members from academia, industry, government shared a common need for a sea-floor installation that could provide more-or-less continuous monitoring of the hydrate stability zone (HSZ).

Gulf of Mexico Hydrates Research Consortium Funding

Funded Jointly by

- Minerals Management Service, Department of the Interior
- National Energy Technology Laboratory, Department of Energy
- Seabed Technology Research Center, a branch of the National Institute for Undersea Science and Technology (NIUST), National Undersea Research Program (NURP) of the National Oceanographic and Atmospheric Administration, Department of Commerce.

Agency Interests

- MMS – Sea-floor stability/instability
- DOE – potential energy resource
- NOAA/NURP – global climate implications

What?

Monitoring Station/Sea-Floor Observatory to provide continuous information from a site within the hydrate stability zone *via*

- geophysical monitoring
- geochemical monitoring
- microbial monitoring

Where?

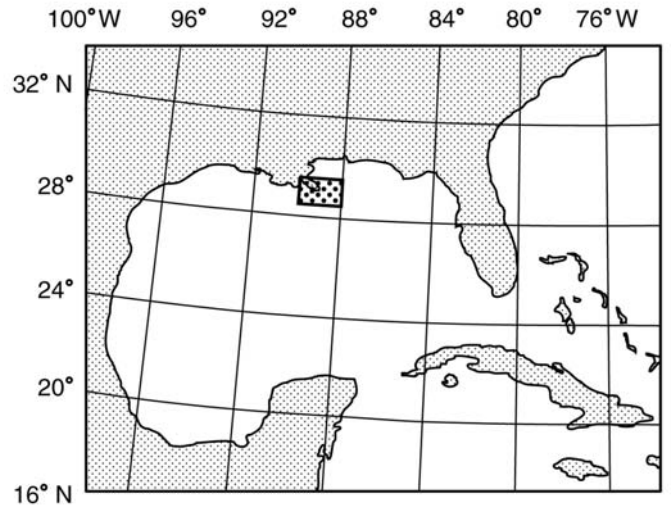
MC118

~150km south of Mississippi Gulf Coast

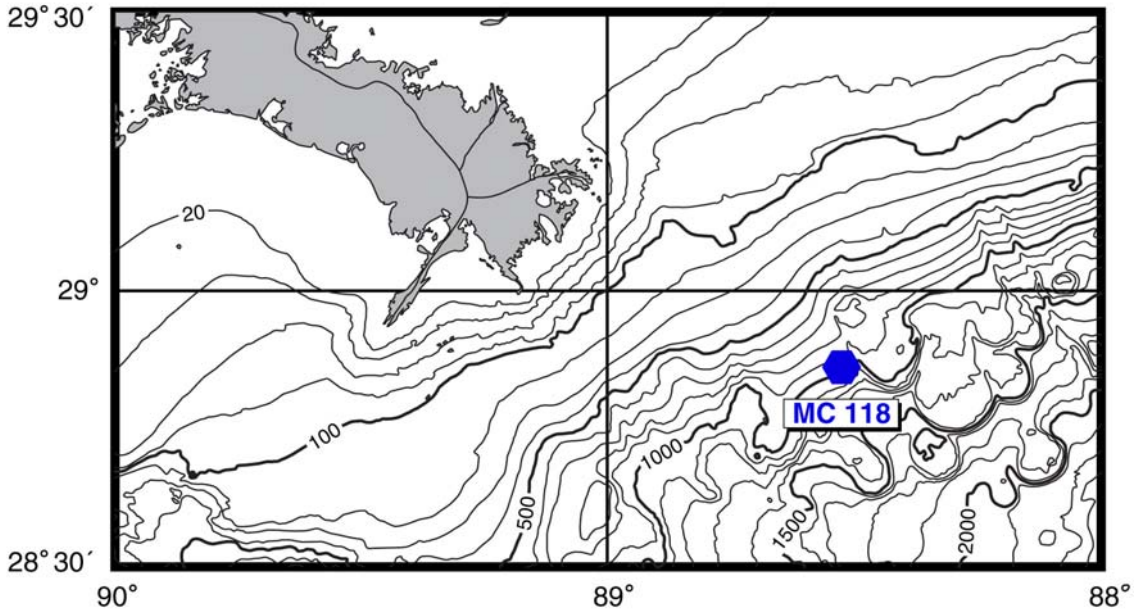
~100km east of the Mississippi Canyon

~900m water depth

On the continental slope, topography at MC118, is dominated by salt features: diapirs, ridges, and minibasins



Area within the Gulf Of Mexico detailed below



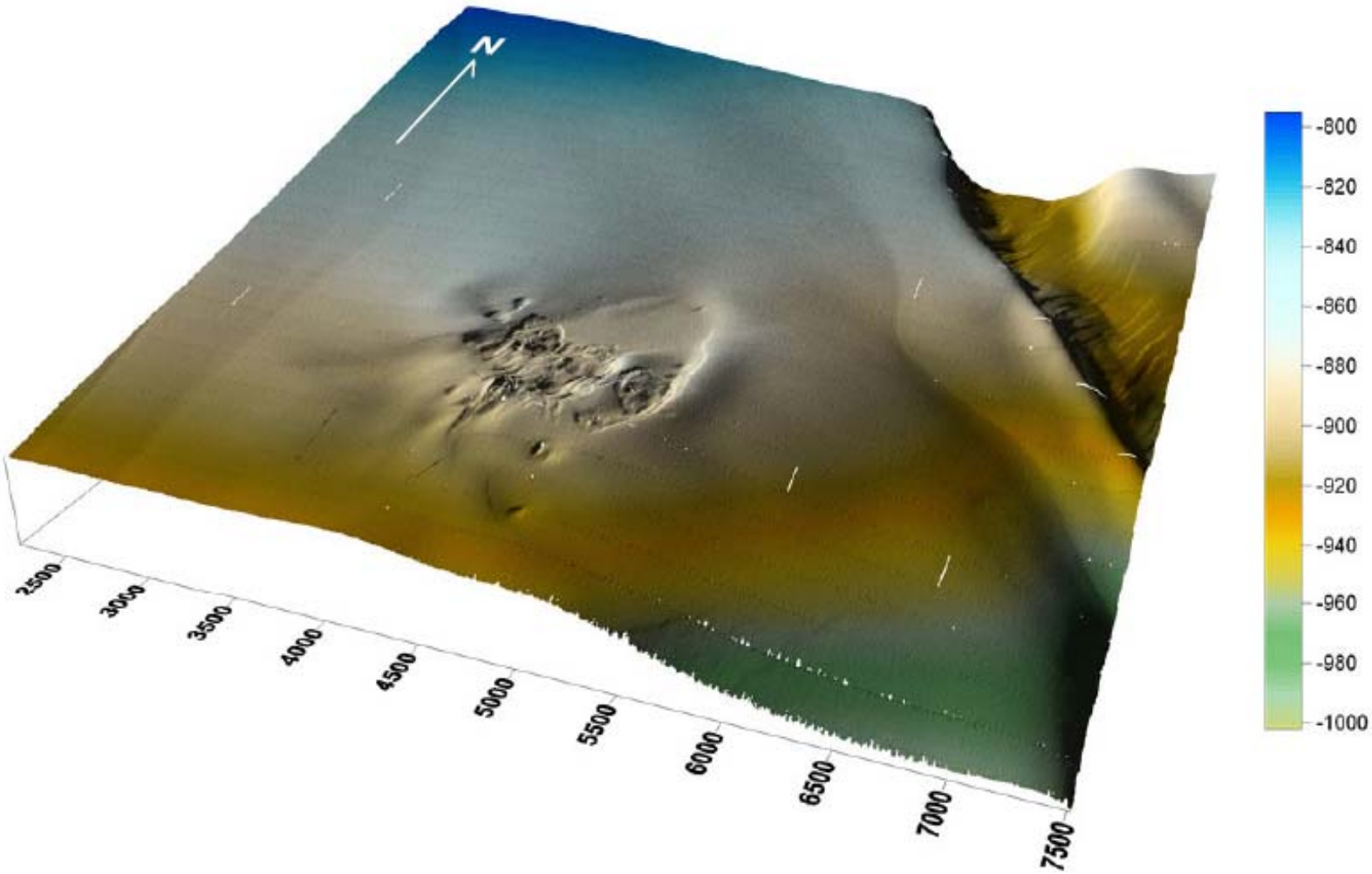
Hydrate outcrop (~6x2x1.5m) extending from crater wall.

Site Characterization

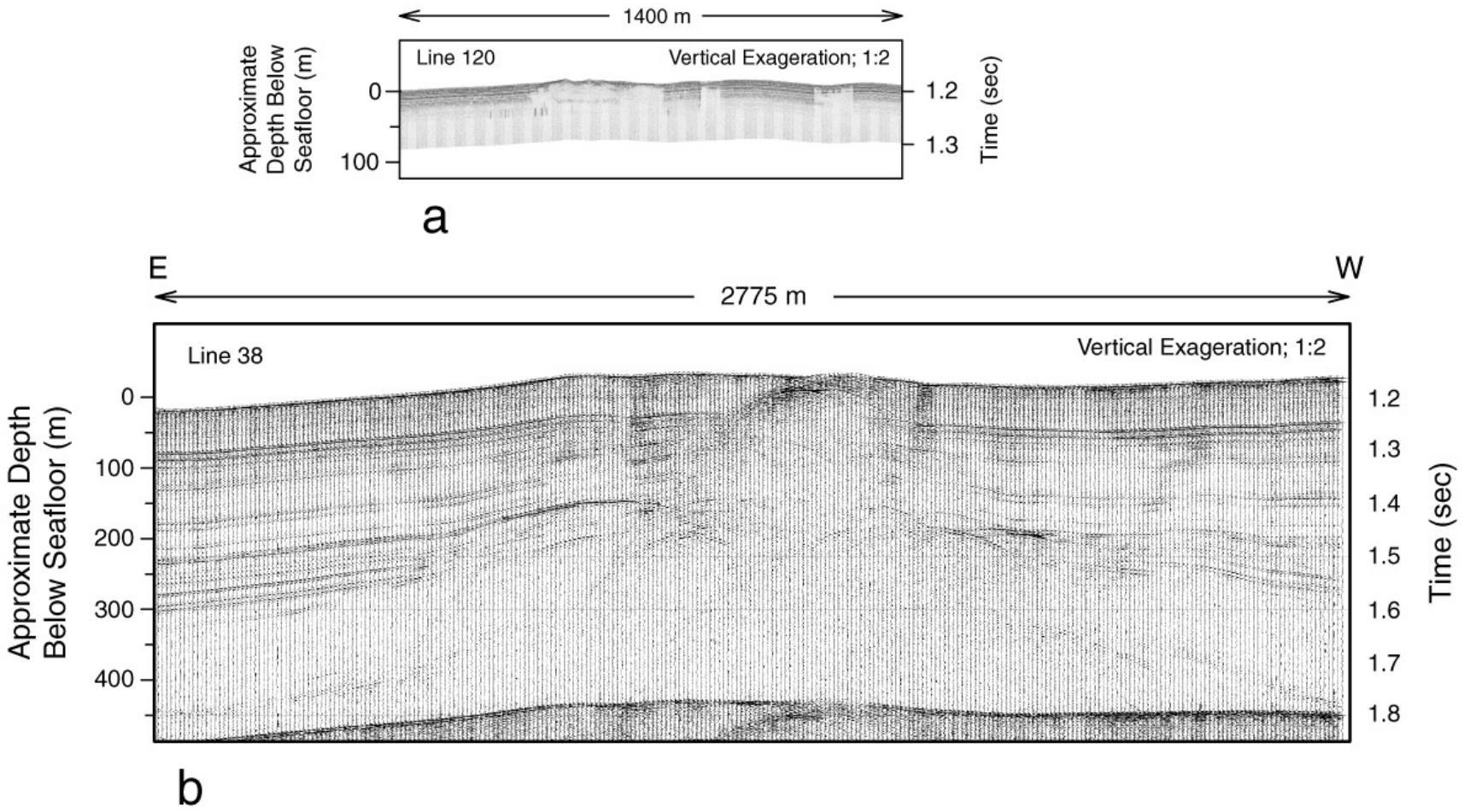
Goal – to understand the past and present geology at the observatory site and to determine the historical role of the hydrates.

The following analyses were pursued:

- Geophysical
  - AUV swath bathymetry, side scan, chirp
  - SSDR
- Geochemical
  - Vent gas
  - Hydrate
  - Pore-fluids
- Geological
  - Cores: lithostratigraphy, biostratigraphy
- Microbial
  - Cores
  - Collectors



Oblique view of AUV swath bathymetry at MC118



Seismo-acoustic profiles:

a) Chirp sonar by AUV, b) SSDR by deep-tow.

Software and Processing Advances

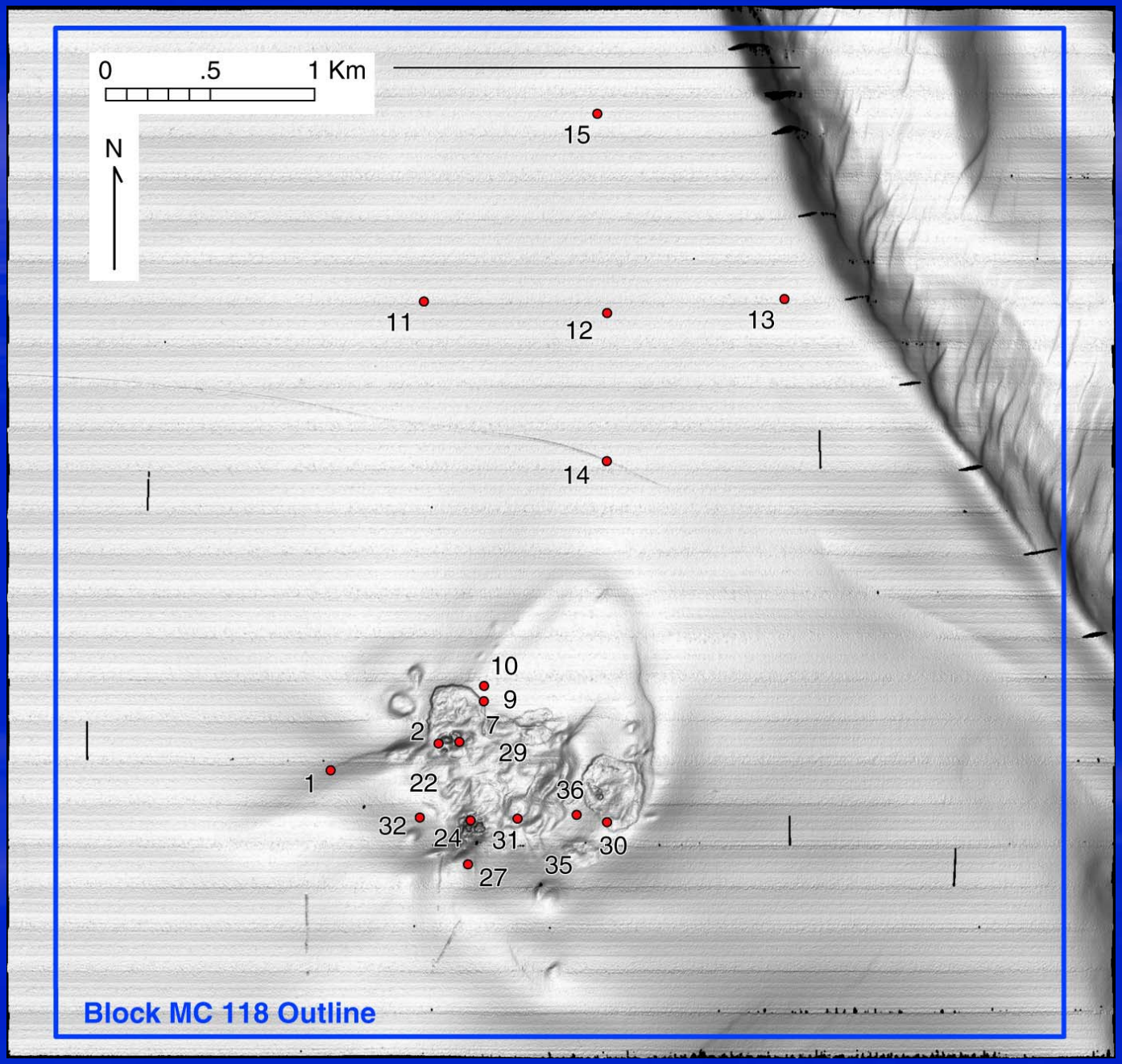
- New Processing Software Packages
  - SSDR and seismo-acoustic array data
  - Polarity preserving chirp sonar
  - Acoustic noise (ship and storm-wave)
  - Passive seismic tomography (microseisms)
- Reprocessing AUV Multibeam Data

Geologic Setting

Gravity cores up to 10m collected during 3 cruises

10m recovery within “reference section” north of the mound

Over the mound, recovery ranged from 0 to 7.4m.

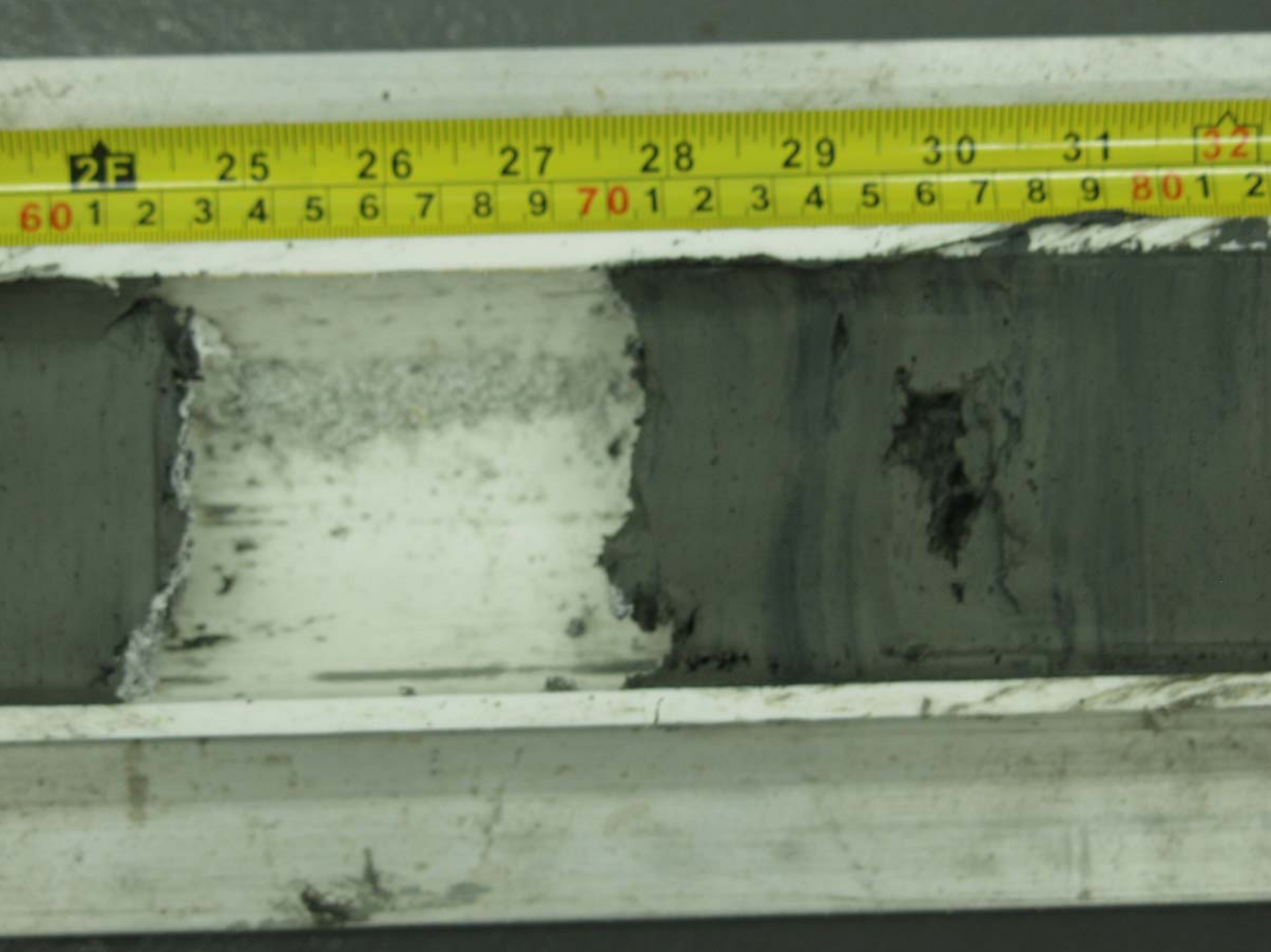


GULF OF MEXICO
HYDRATES RESEARCH CONSORTIUM

Core Analyses

Cores were subsampled for microbial, geochemical, lithostratigraphical and biostratigraphical analyses.

Gassy samples were canned for gas analyses.


25 26 27 28 29 30 31 32
60 1 2 3 4 5 6 7 8 9 70 1 2 3 4 5 6 7 8 9 80 1 2

Geochemistry

Pore-fluids sampled for salinity, sulfate, hydrocarbons

*2002 samples:
vent gas & hydrate both
consistent with deeply buried oil source

What the Cores Have Told Us

Sediments are fine-grained with minor foraminiferal sand

<50cm BSF, microbes dominate methane production

>50cm BSF, methane is thermogenic

Gassy sediments – vertical fluid flow along faults and fractures conducive to microbial activity

Litho- and biostratigraphy are typical for the Gulf in “reference section” but atypical over mound.

Sedimentation rates typical for the Gulf prevail in the reference section but are greatly reduced over the mound, suggesting tectonic activity related to the mound.

OBSERVING SYSTEMS

How changes in the HSZ affect the seafloor, the subseafloor and the water-column

- Geophysical
- Geochemical
- Microbial

Monitoring Station Observing Systems

Geophysical – six linear sensor arrays
water-column array, borehole Array, horizontal arrays
GOAL – to monitor physical changes in the HSZ

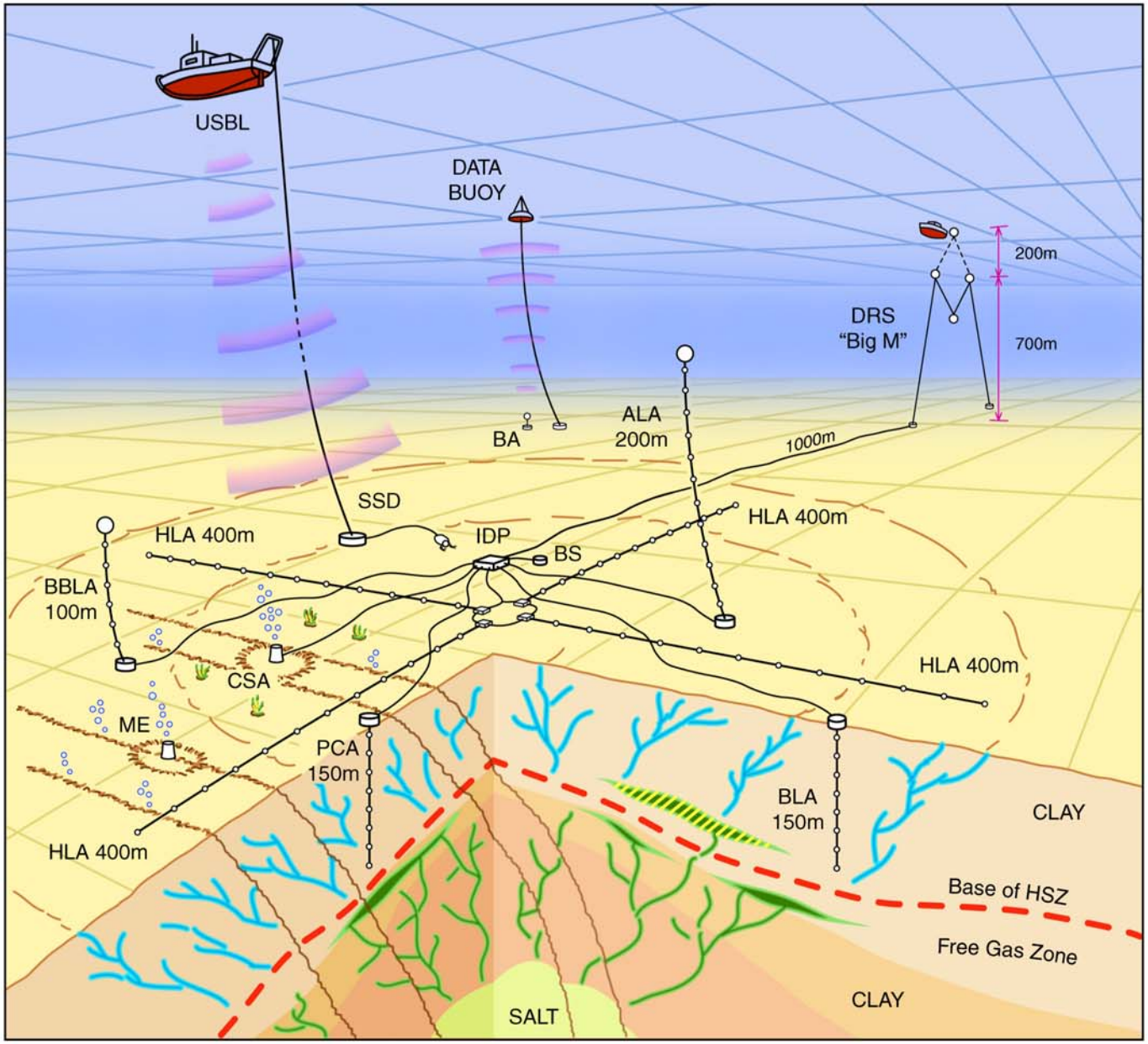
Geochemical – samplers
within sediments, at the sea-floor, lower water column
GOAL – to detect changes in geochemistry that translate to shifts of hydrate stability zone

Microbial – in situ samplers, cameras
relationships between microbes and hydrates
GOAL – to determine how microbes affect the HSZ

Monitoring Station Support Systems

Support Systems

- Data Recovery System – data-loggers
  - Telemetry Buoy
  - Integrated Data Power Unit – the Brain
  - Battery System
- Station Service Device



Hemipelagic Mud (thickness unknown)

Base of Hydrate Stability Zone (BHSZ)

Known Hydrate Mound with Gas Vents

Free Gas

High Pressure Gas Sand

Hydrates

Fault Zone

ALA	Acoustic Line Array
BA	Bottom Accelerometer
BBLA	Benthic Boundary Layer Array
BLA	Borehole Line Array
BS	Battery System
CSA	Chimney Sampler Array
DRS	Data Recovery System
IDP	Integrated Data Power Unit
HLA	Horizontal Line Array
ME	Microbial Experiments
PCA	Pore-fluid Circulation Array
SSD	Station Service Device
USBL	Ultra-short Baseline

Gas Hydrate Sea Floor Observatory - Mississippi Canyon Block 118

Installation

The first observing systems, a pore-fluid sampler and an array of sub-bottom thermistors, were installed in May 2005.

PEL ICAN

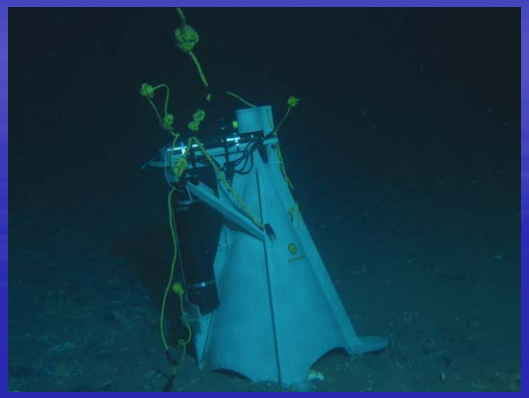
AMERICA'S CUP

2006 Johnson Sea Link dives at MC118

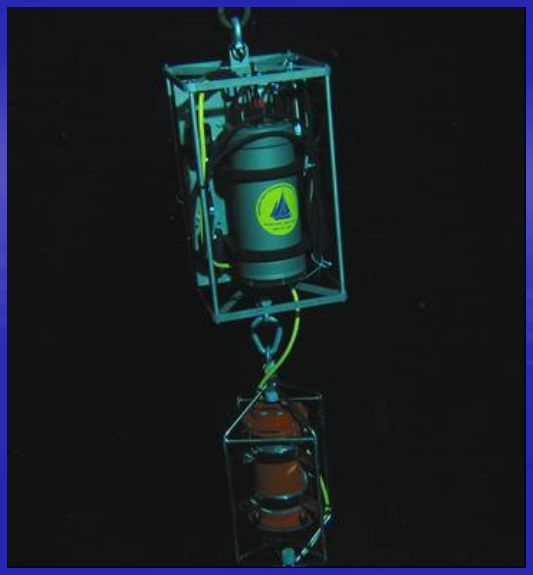
Pore-Fluid Sampler

Replacing the osmosamplers

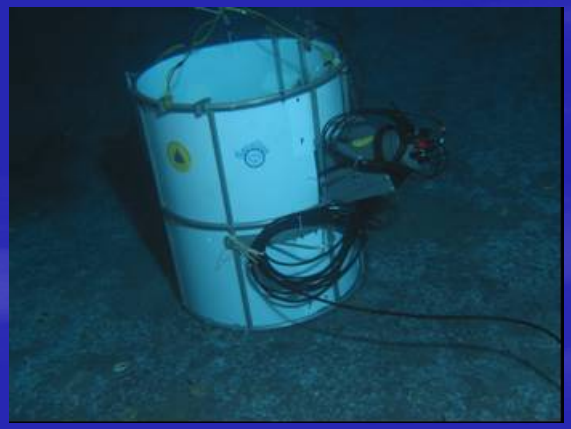
Deployment of Geochemical Arrays



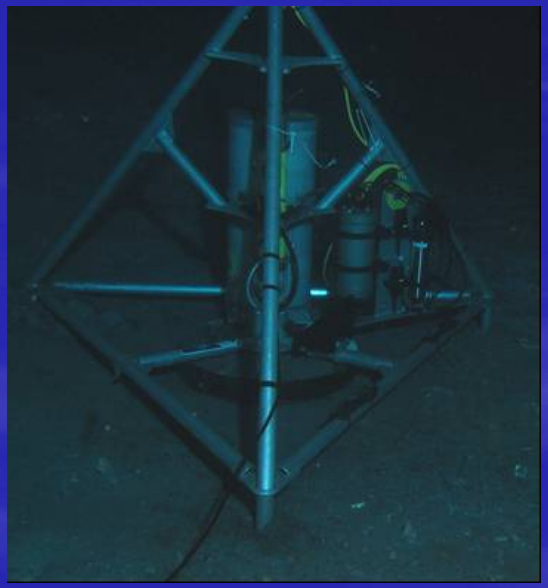
Electromagnetic Flux Meter



Chimney and Lander on Dock

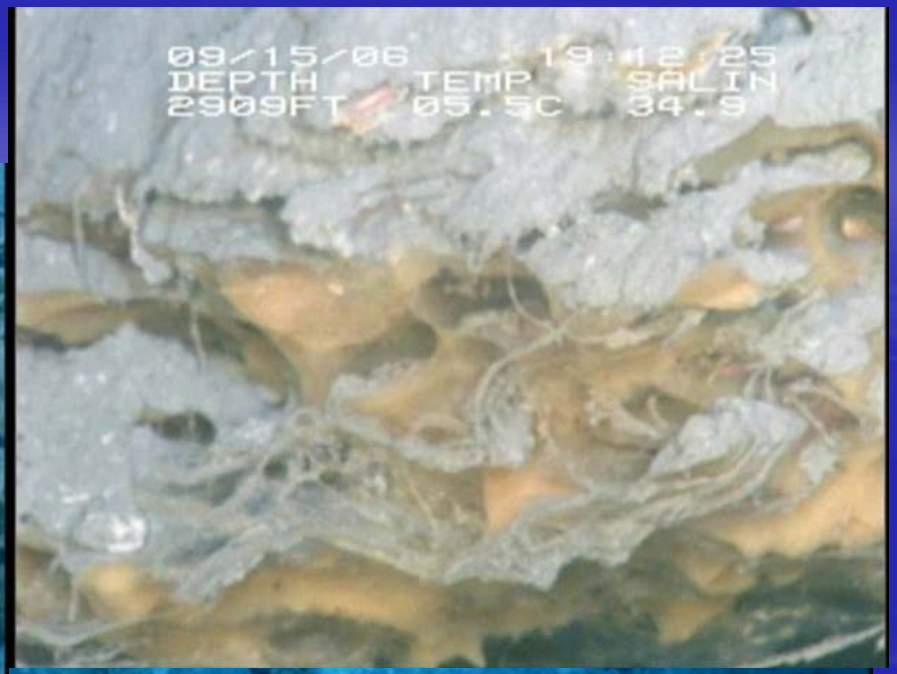


Chimney Sampler Array

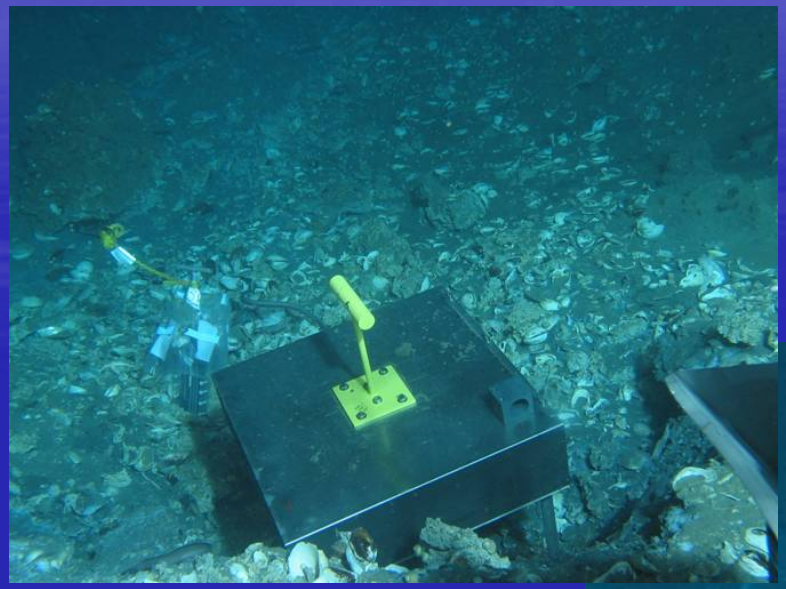


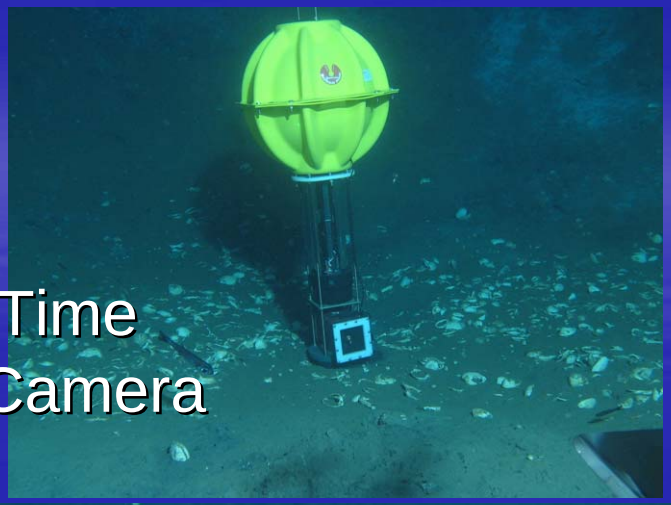
Benthic Boundary Layer Array

Life at MC118

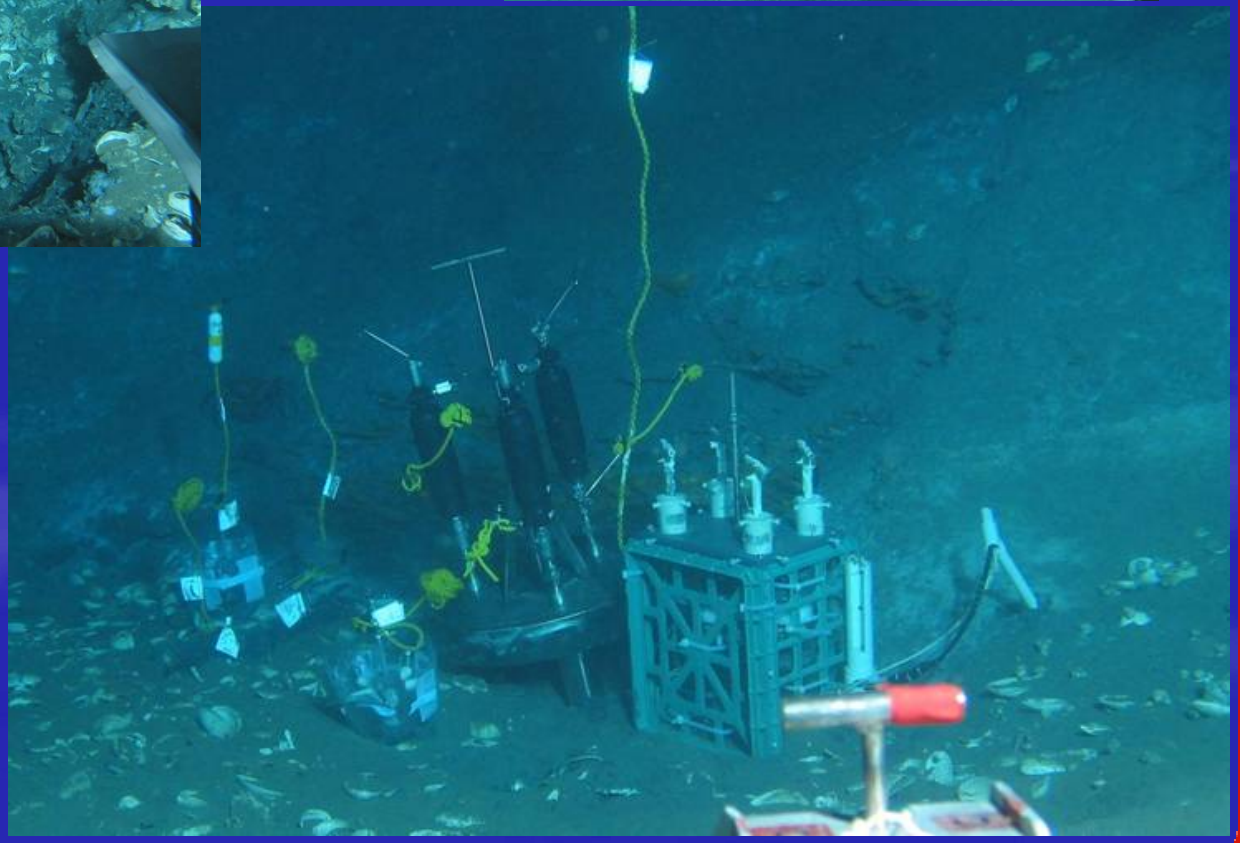


Microbial Experiments





360^0 Time Series Camera



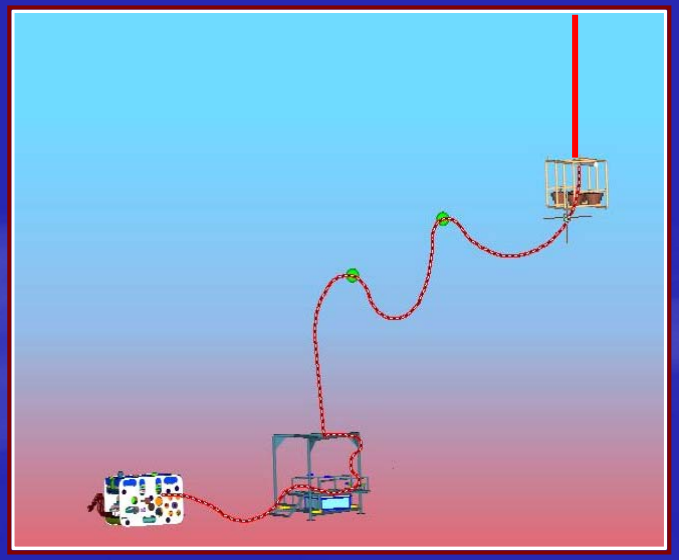
Microbial Sampler

Hydrate Synthesizer

Pore-fluid samplers

Station Service Device – Custom ROV

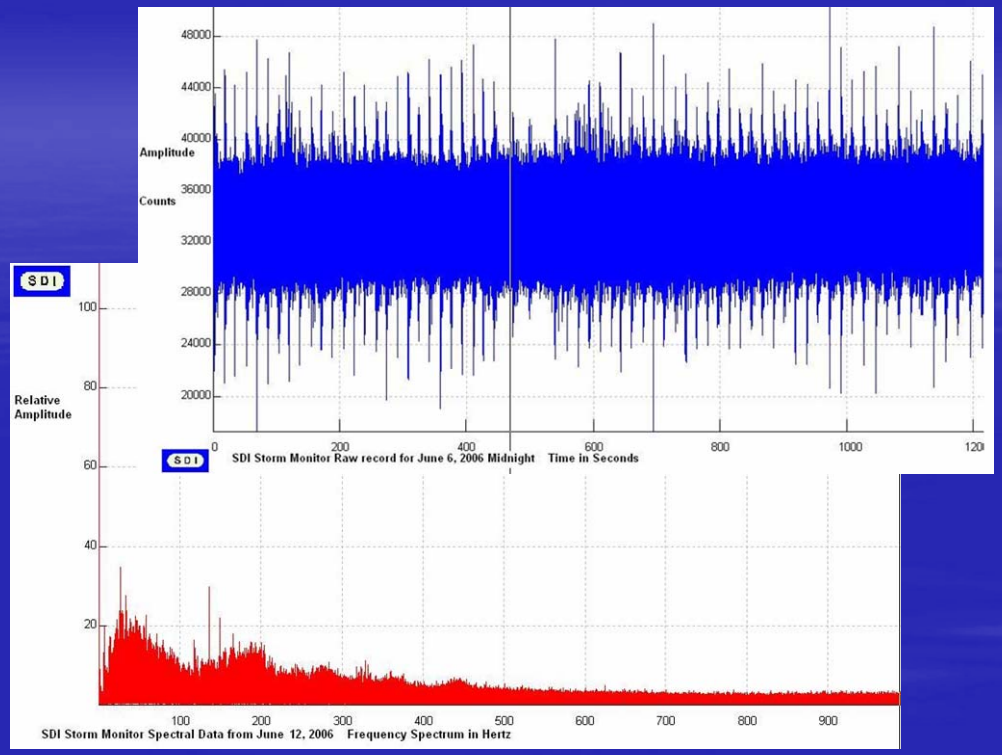
Battery Powered – access to greater depths
Dynamic trim (ballast and floatation)
Tether spool on vehicle
Does not require Dynamically Positioned ship



Storm Monitor

Deployed June, 2006
Recovered 180 hours of data over 135 consecutive days of hurricane season

Data shown are from June 12 and represent sound of Tropical Storm Alberto



Storm monitor printed circuitry and pressure compensated chamber

What's Next?

2007

- Install Data Recovery System
- Install vertical array
- Make connections to IDP
- Perform test runs
- Collect and process vertical array data
- Complete horizontal arrays

2008? – Transmit data to shore in near-to-real time for true monitoring capability

ACKNOWLEDGMENTS:

- AUV surveys were done by C&C Technologies of Lafayette, LA.
- Post processing of the multi-beam data was done at the Department of Earth Science of the University of Rome, La “Sapienza” and at the CMRET by Alessandro Bosman, Leonardo Macelloni and Simona Caruso.
- SS/DR data were processed by Leonardo Macelloni, CMRET.
- Chirp lines were processed by Ken Sleeper.
- Mike Richardson, Seafloor Sciences Branch of the Naval Research Laboratory at Stennis Space Center kindly made the GEOTEK Multi-Sensor Core Logger available for our use and Chad Vaughn of NRL assisted in logging and calibrating the cores.
- Figures were ably prepared by Paul Mitchell.

Funding for the Gulf of Mexico Hydrates Research Consortium is provided by the Minerals Management Service (MMS) of the Department of the Interior, the National Energy Technology Laboratory (NETL) of the Department of Energy and the National Institute for Undersea Science and Technology (NIUST) of the National Oceanographic and Atmospheric Administration (NOAA) of the Department of Commerce.

Center for Marine Resources and Environmental Technology

The University of Mississippi

cbl@olemiss.edu

662-915-7320