NRL Gas Hydrates Research

- Core Funding from ONR
- External Funding from DOE

Overview of Presentation

- Personnel
- Background Information
- Scientific Objective, & Approach
- Results from Project
- Future Direction

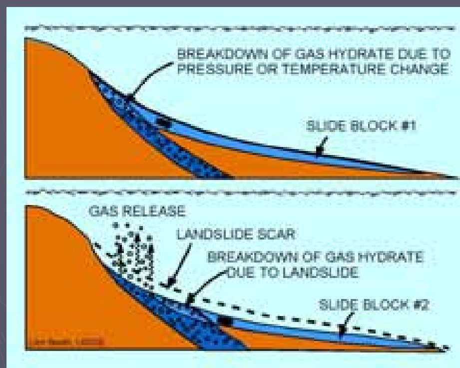
Base Program:
Gas Hydrates
Accelerated Research Initiative (ARI)

- Multi-Division Effort
  - Geology/Geophysics
  - Chemistry
  - Material Sciences
- Field Studies based on Deep-Tow MCS & Geochemical samples
- Numerical simulations to Develop Predictive Capabilities
- In the 4th year of 5 year project.
- A follow on ARI in FY05

Hydrates ARI
Why is the Navy Interested?

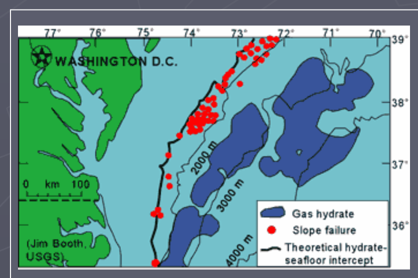
- Slope Stability Issues
  - Bottom Mounted Systems
  - Cables, Pipelines
- Geoacoustic Issues
  - Reverberation (Active ASW Sonars)
  - False Targets (Passive ASW Sonars)

Why is Methane Hydrate Important?

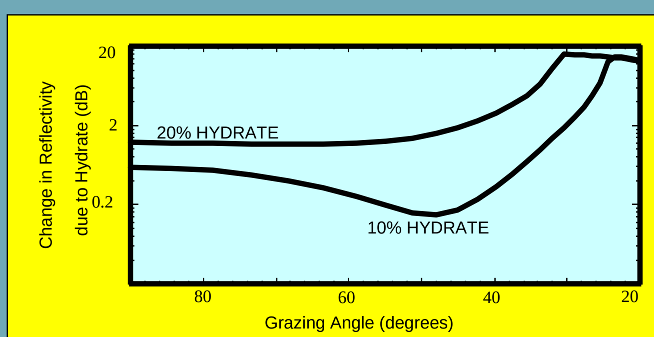


Methane hydrate may act as a pressure and temperature sensitive cement, resulting in slope failure in times of sealevel fall or bottom water temperature increase.

Head walls of slope failures on the U.S. East coast coincide with the intersection of the base of hydrate stability with the seafloor.



REFLECTIVITY OF HYDRATE CEMENTED SEDIMENT



Even small amounts of hydrate can alter sediment P & S velocities (computed via time average after Wood et al., 1994) enough to significantly increase reflectivity at small grazing angles.

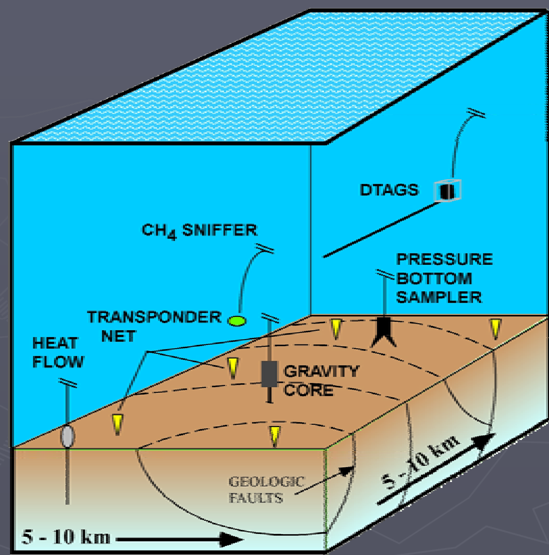
Objective
Hydrates ARI

Develop quantitative numerical models to predict the impact of gas hydrate dynamics on the geoacoustic and geotechnical properties of marine sediments.

Hydrates ARI
Approach

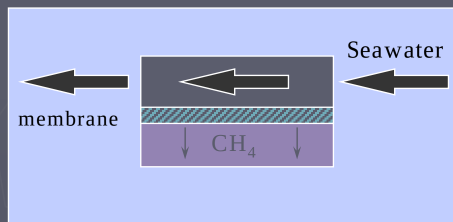
- Exploit unique NRL instrumentation including deep-tow multichannel seismic (DTAGS), Trace Element Accelerator Mass Spectrometer (TEAMS), etc.
- Co-locate samples (within ~2 m)
- Use information gained to develop improved understanding and predictive capabilities

Canonical Experiment for the ARI

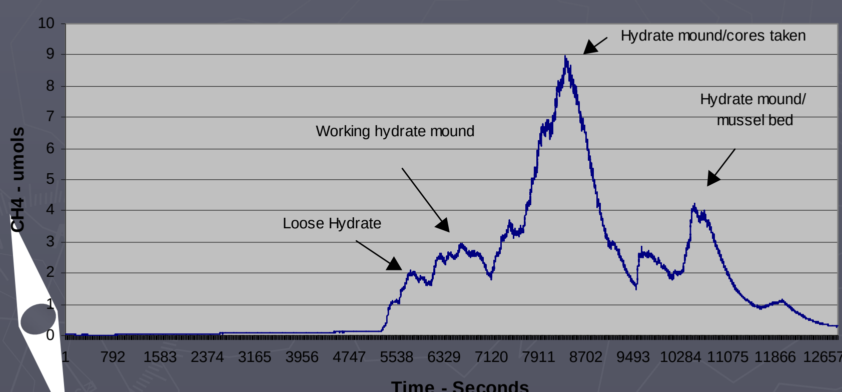


Chemistry & Materials Science Hydrates Research at NRL

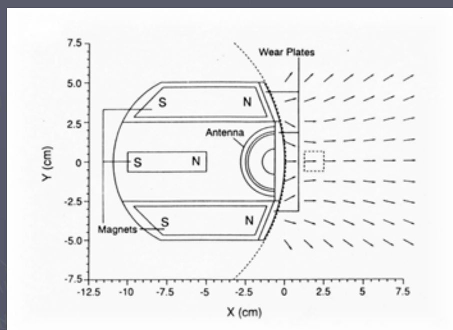
Methane Sensor Technology



In Situ Application of the Methane Sensor

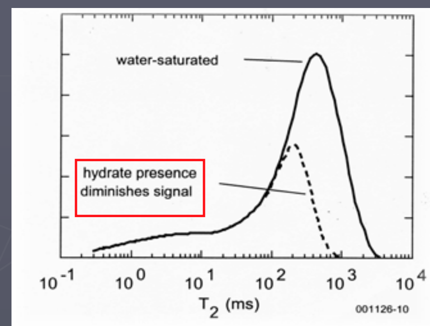


In Situ NMR Application



System contains three magnets and an RF antenna. The system is pressed against the wall of a borehole. Arrows indicate the direction of the static magnetic field.

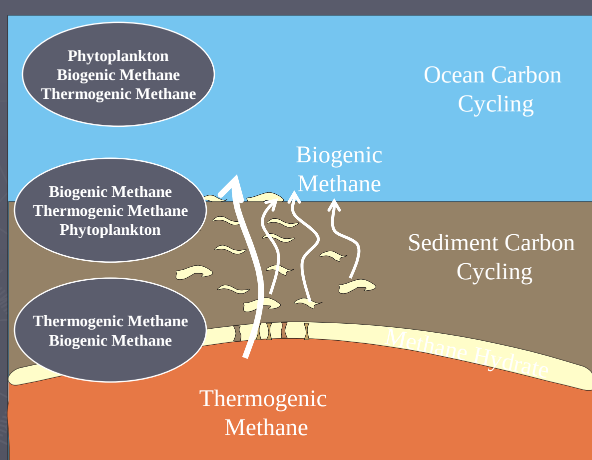
Diagram provided by Peter Brewer (MBARI), Robert Kleinberg (Schlumberger-Doll Research), James Yesinowski (NRL)

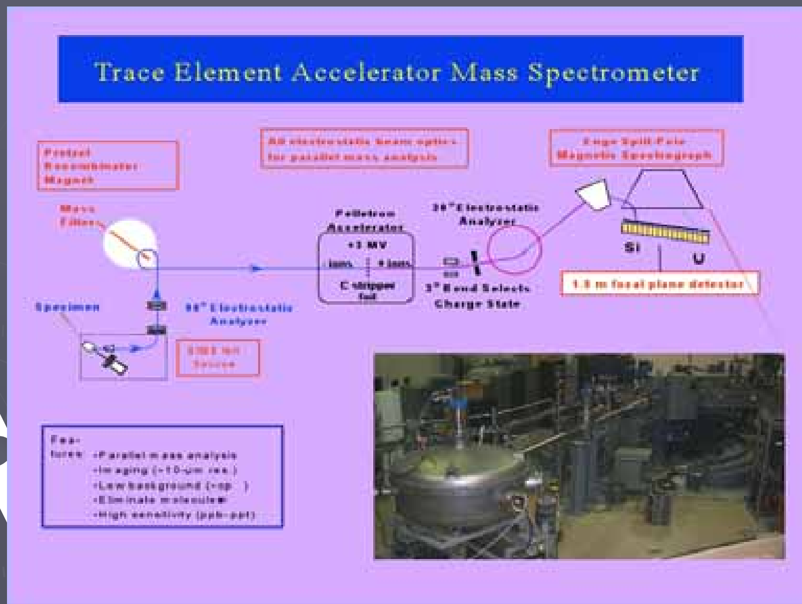


Representation of NMR relaxation time distribution for fully water-saturated rock, and for hydrate occupying the largest pores of the seam rock.

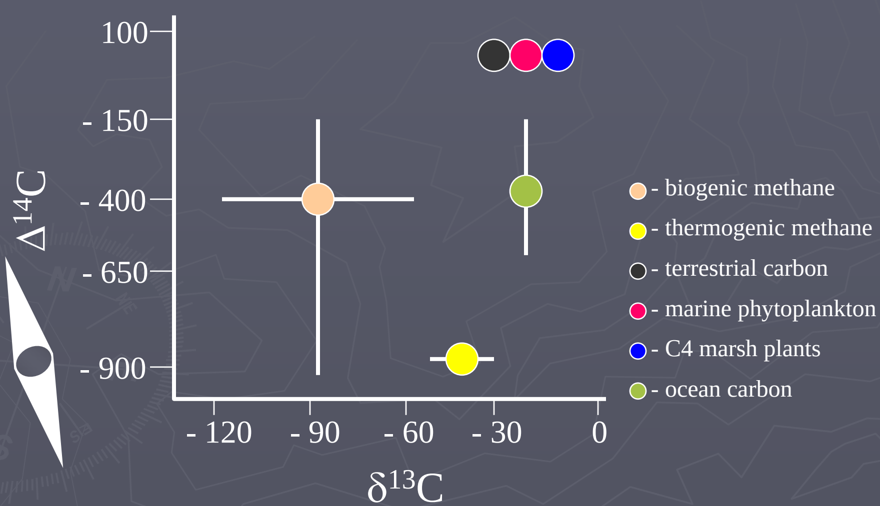
Schematic diagram provided by Robert Kleinberg (Schlumberger-Doll)

Source and Fate of Methane





Two Dimensional Carbon Isotope Analysis

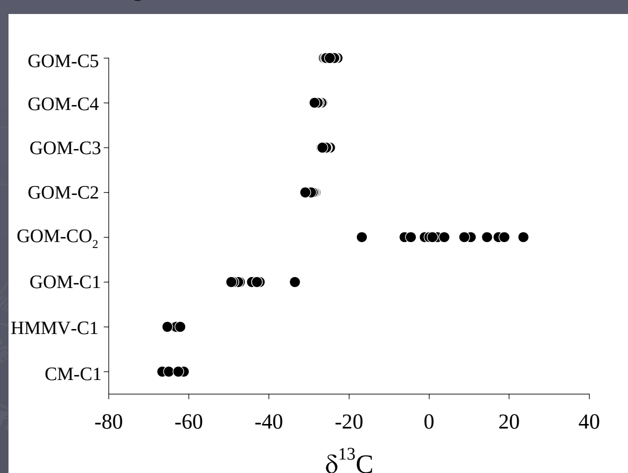


Hydrate Content

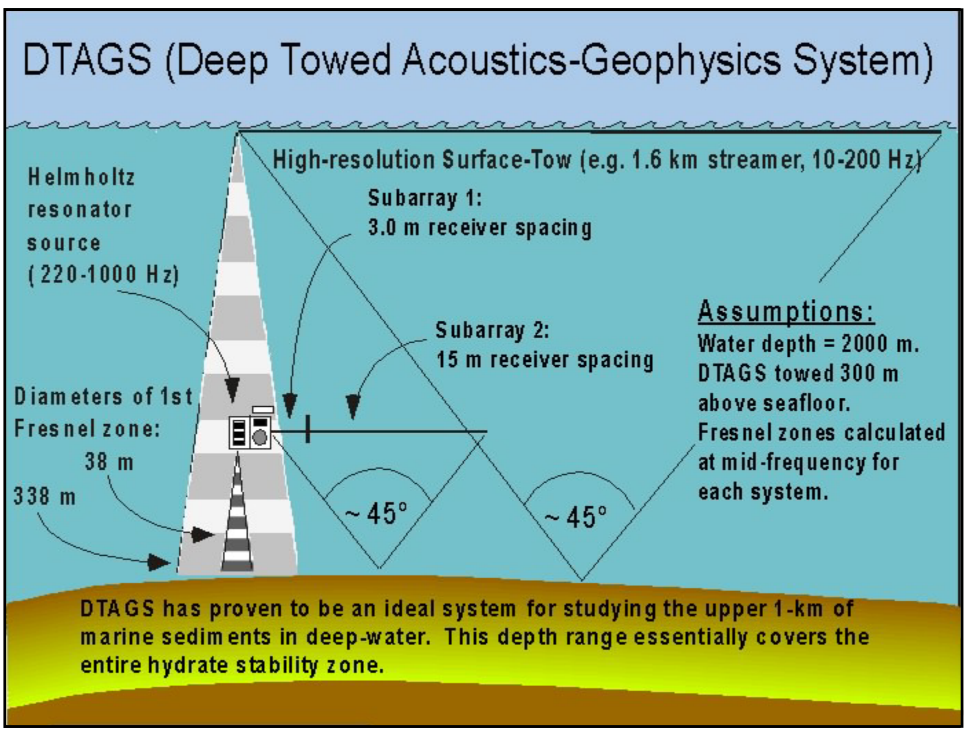
	% Hydrocarbon composition						
Sample ID	C_1	C_2	C_3	*i* - C_4	C_4	C_5	C_6
Haakon Mosby MV	99.5	0.1	0.1	0.1	0.1	0.0	0.1
Bush Hill White	72.1	11.5	13.1	2.4	1.0	0.0	0.0
Bush Hill Yellow	73.5	11.5	11.6	2.0	1.0	0.1	0.2
Green Canyon White	66.5	8.9	15.8	7.2	1.4	0.1	0.1
Green Canyon Yellow	69.5	8.6	15.2	5.4	1.2	0.0	0.0
Bush Hill	29.7	15.3	36.6	9.7	4.0	3.2	1.6

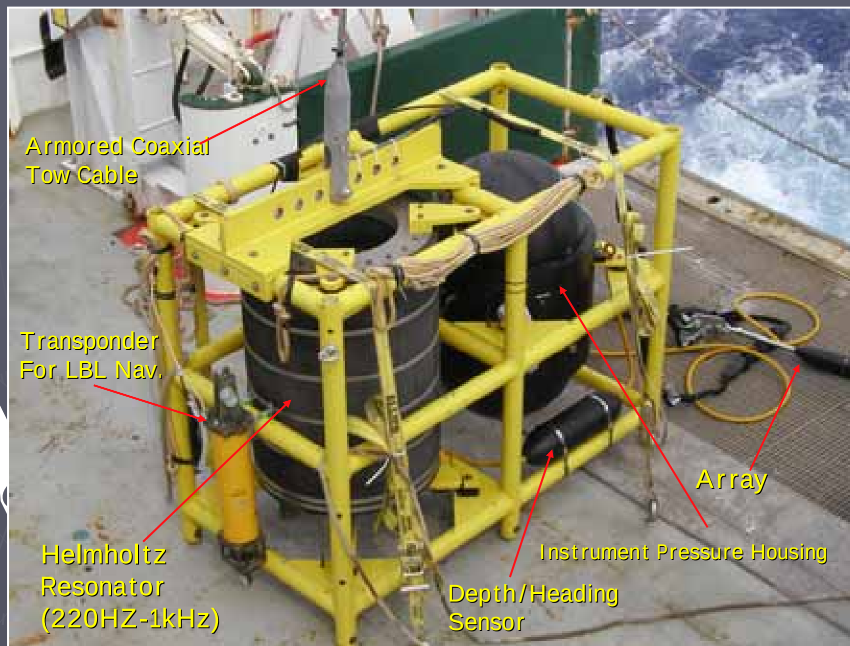
Evidence for Structure H

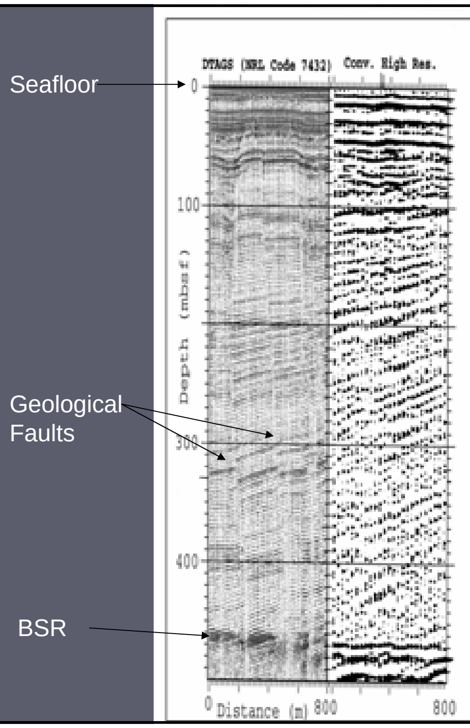
Hydrate Gas $\delta^{13}C$



Geology/Geophysics Hydrates Research at NRL





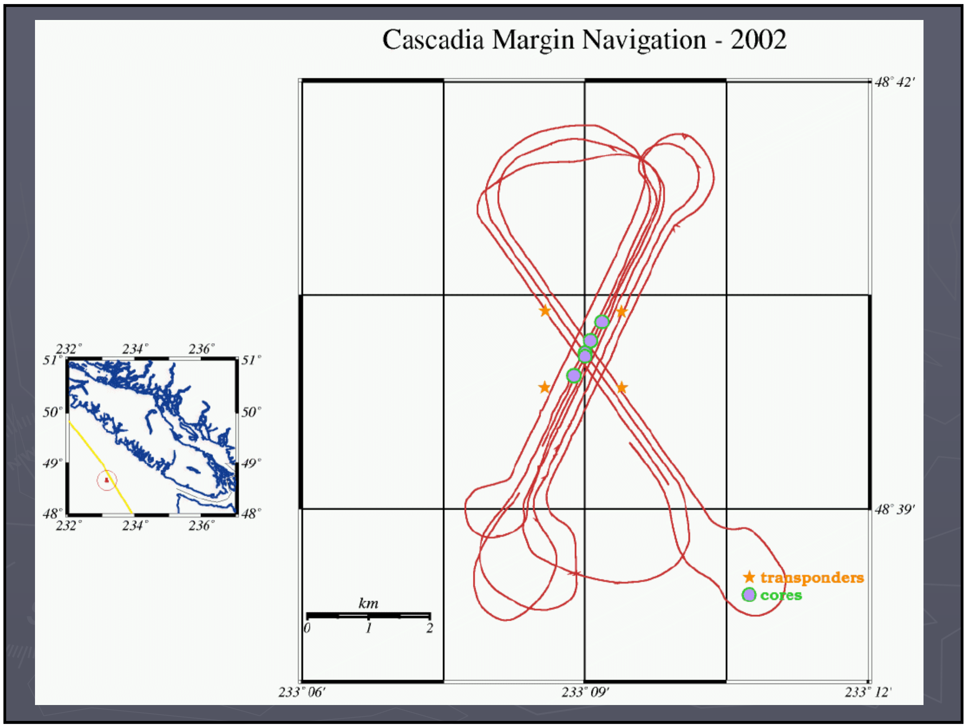


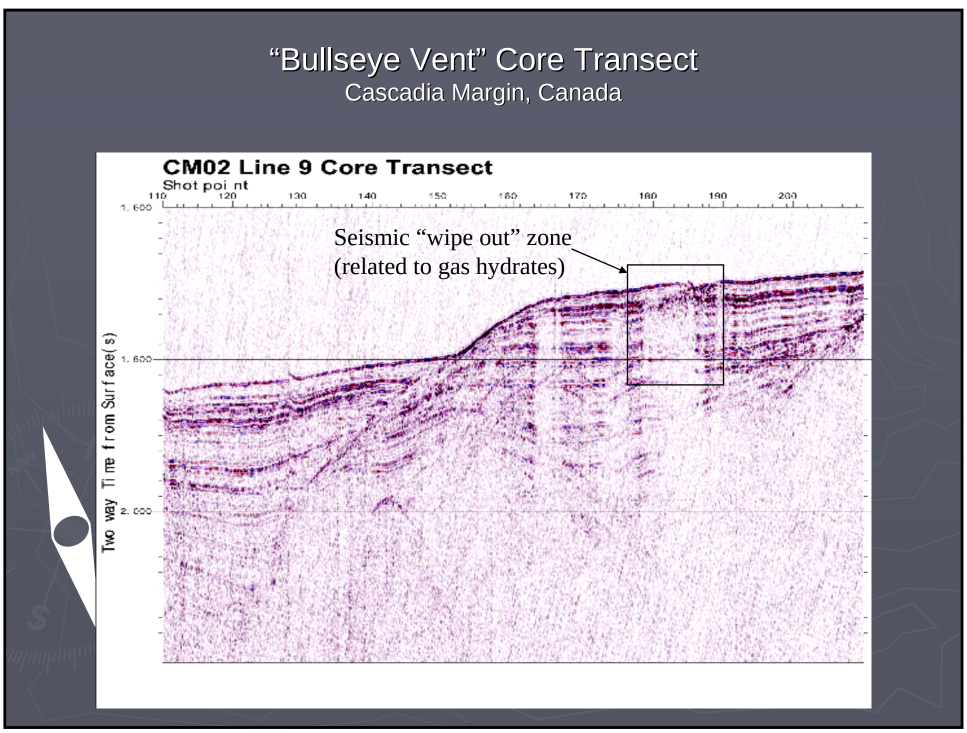
The order of magnitude improvement in both vertical and lateral resolution of DTAGS data (250-650 Hz) over conventional high-resolution single-channel air gun data data (10-220 Hz), Line 31 from Katzman et al., 1994 is clearly shown in this figure.

The very sharp images of the growth faults ubiquitous on the Blake Ridge (Rowe and Gettrust, 1994) are confirm that these faults extend through the hydrate stability zone.

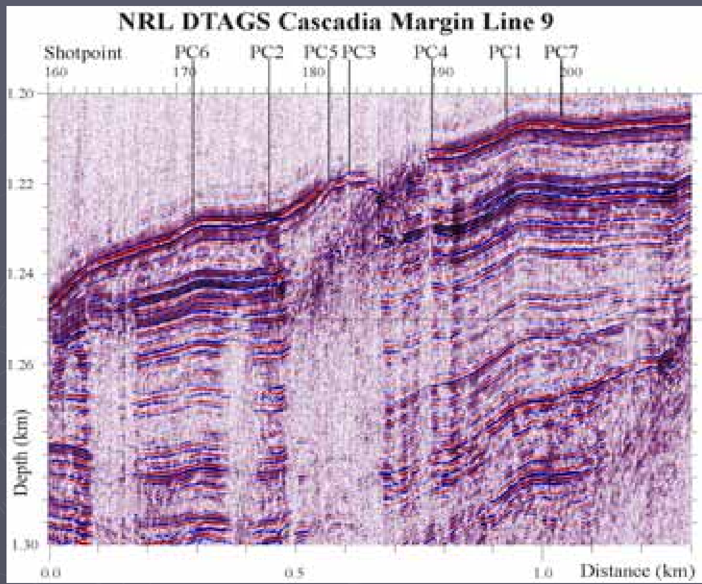
The DTAGS data shown here were recorded ~1km south of the site where the Katzman et al. data were taken (near ODP Site 997).

Both of the data sets presented are converted to depth using the interval velocities from Holbrook et al., 1996 for Site 997.


Cascadia Margin Navigation - 2002
48° 42'
48° 39'
233° 06'
233° 09'
233° 12'
km
0
1
2
transponders
cores
232°
234°
236°
51°
50°
49°
48°

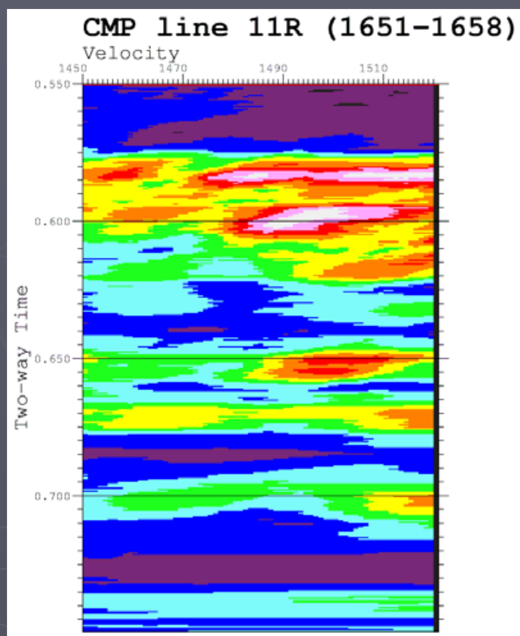

"Bullseye Vent" Core Transect
Cascadia Margin, Canada
CM02 Line 9 Core Transect
Shot point
Seismic "wipe out" zone
(related to gas hydrates)
Two way Time from Surface(s)

Bullseye Blowup

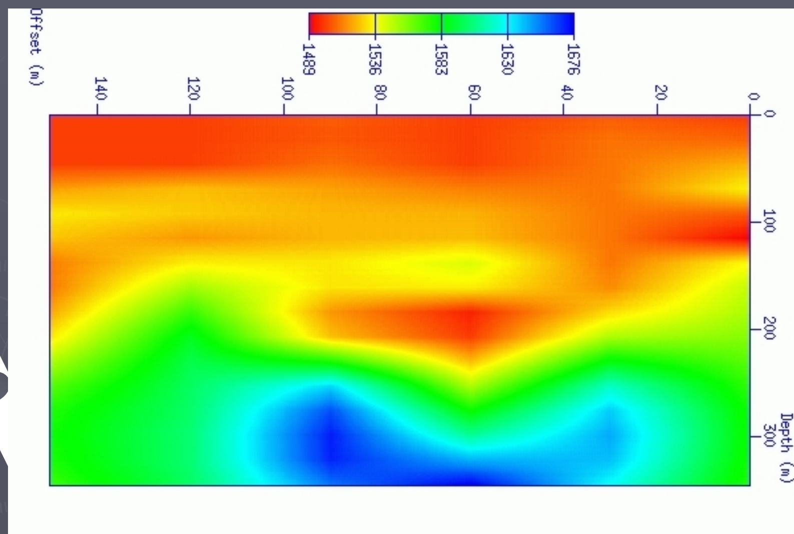


Compressional Velocity Estimates:

Semblance panels are used to estimate average compressional velocities.
As source & receiver depths are not the same, codes have been developed to account for vertical offsets.



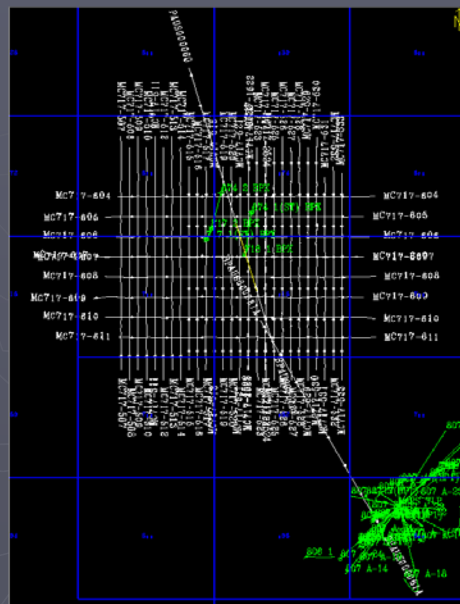
Velocity -Depth for ~150 m Section on Cascadia Margin
(note significant lateral variability resolved with DTAGS data)



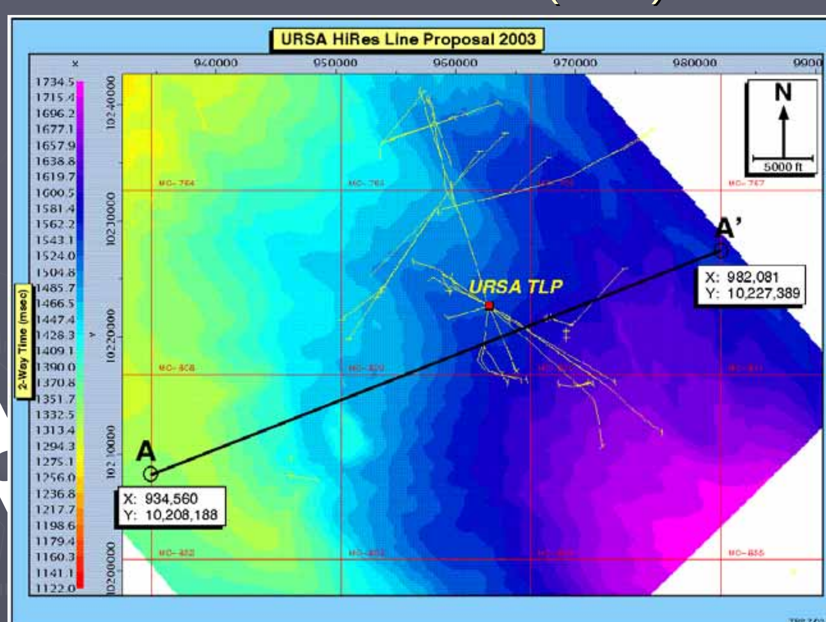
Gulf of Mexico - 2003

- Shallow water flow
- JIP

Shallow Flow Sites - Mars/Ursa



Shallow Flow Sites (cont.)



Atwater Valley Site

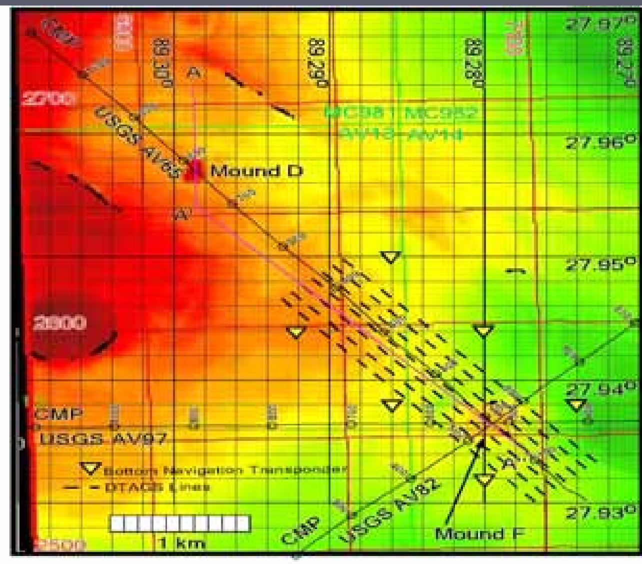


Figure 1. Atwater Valley 14. This block lies in the relatively flat floor of Miss. Canyon at about 1300m water depth. Transect A-A' crosses north to south over mound D and transect A'-A'' NW to SE over mound F. USGS lines AV65, AV97, and AV82 all cross at mound F.

Keathly Canyon 195 Site

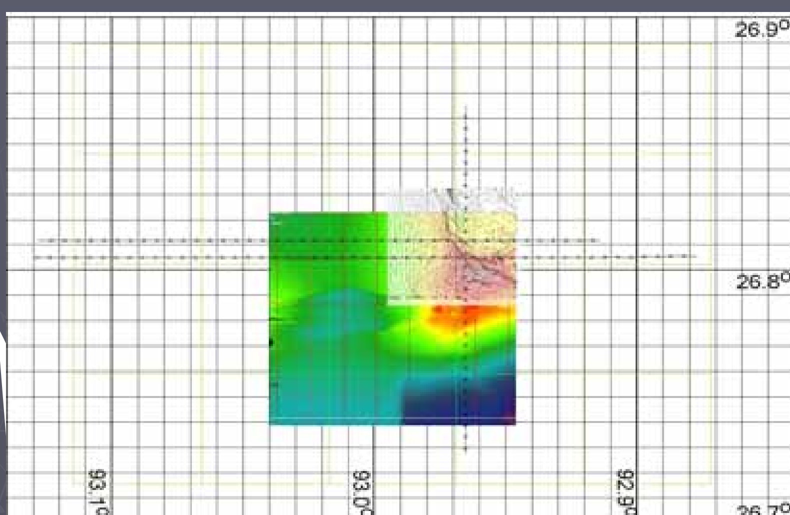


Figure 4. Keathly Canyon 195. This block also lies in about 1300 m of water but in an area more tectonically typical of the hydrocarbon rich salt province. The bathymetric high crossed by B-B' (Fgiure 4) is a large fault ridge controlled by upward moving salt. The relatively unperturbed region to the west and north of the ridge is a salt-withdrawal min-basin.

Piston Core Locations

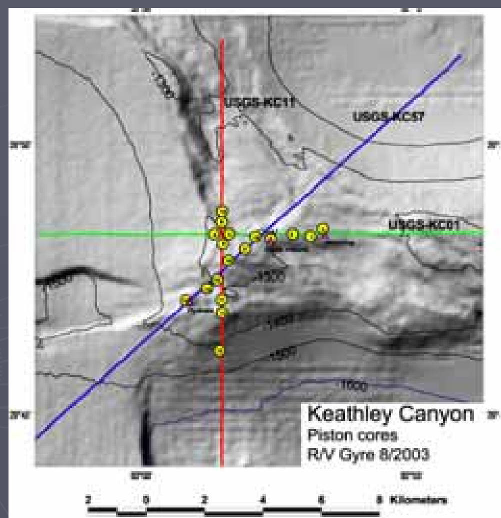
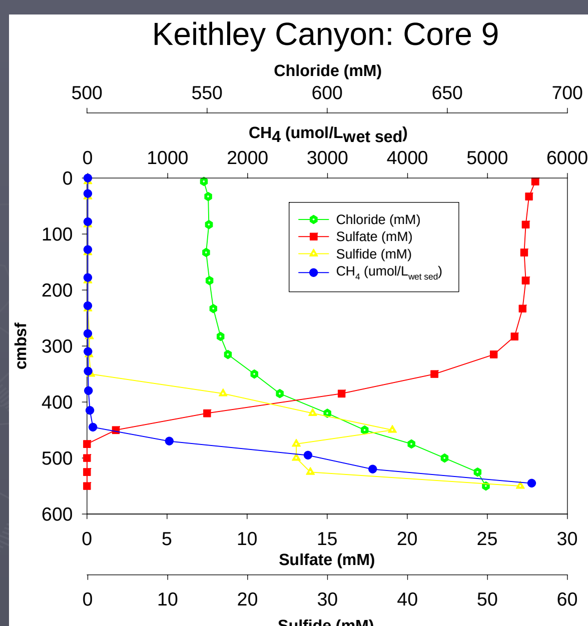


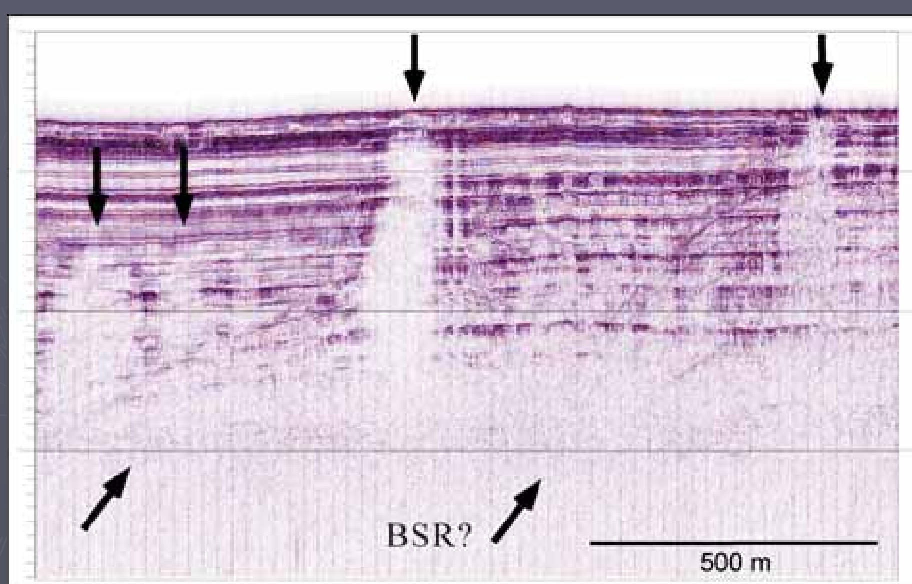
Chart provide by Carolyn Rupple GTU



Numerical Simulations of Processes Related to Hydrate Dissociation/Generation

- Taking two approaches
  - Finite element diffusion equation for larger-scale simulation of fluid flow, heat transport.
  - Lattice Gas approach to investigate fluid flow through complex media with multi-component material.

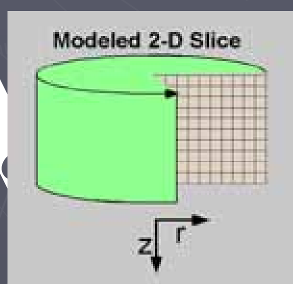
Cascadia Vent Field Wipeouts

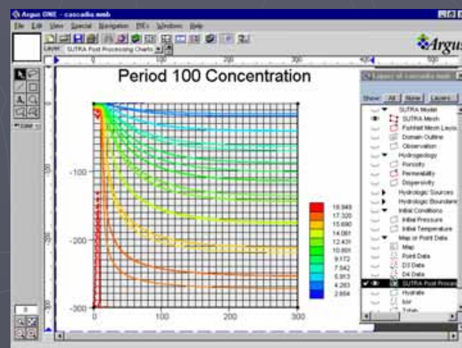


Computer Simulation

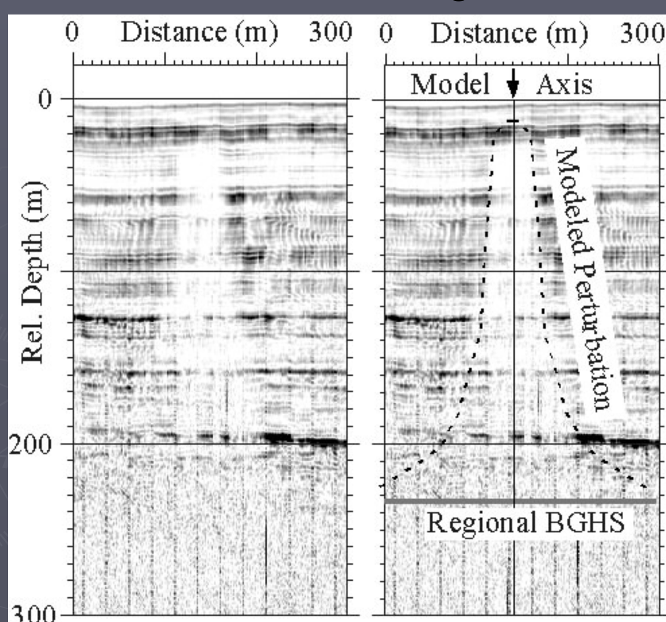
Finite Element – SUTRA

- **Advantages:** well established industry standard, relatively easy to use
- **Disadvantages:** Single non-reactive constituent only; each quantity (e.g. heat, methane, etc.) must be modeled separately





Application to Cascadia Margin Observations



Lattice Gas Simulations

- Multi-components
- Drive with heat, gravity, external bias
- Miscible and/or immiscible properties
- Complex geometries
- Requires high-performance computer support.

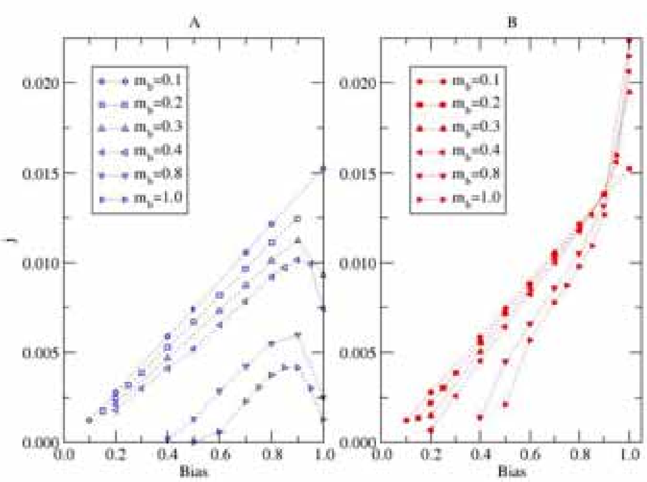
Issues Addressed with Lattice Gas Simulations

- Linearity of flow through faults. What happens when flow rates exceed Darcy's Law? This may be the situation in Cascadia Margin "wipe-out" zones.

QuickTime™ and a YUV420 codec decompressor are needed to see this picture.

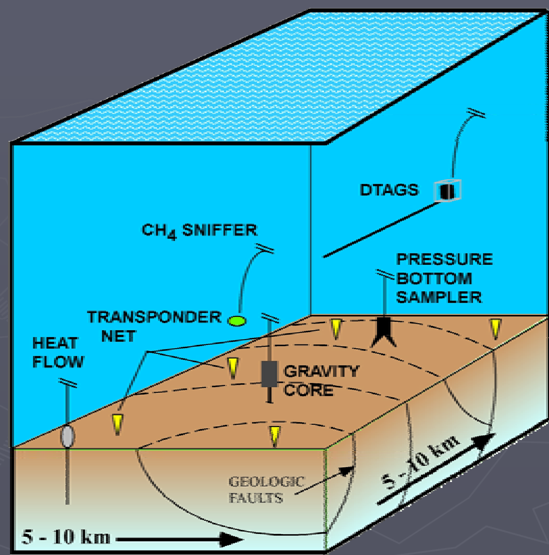
Flux Density (FD) of Light & Heavy Particles

Light Particles (Ma = 0.1)



FD of light particles *FD of heavy particles*

Gas Hydrates ARI



Future Directions

- New Hydrates ARI has been funded (begins FY05)
  - Focus on methane seeps
  - Multidisciplinary
  - Build on techniques developed during current project (especially acoustic navigation)
  - Add heatflow and microbiology components