DOE-NETL Project Kickoff Meeting Morgantown, WV January 9, 2007

Seismic Gas Hydrate Quantification by Cumulative Attributes (CATTs)

DE-FC26-06NT42961

ROCK SOLID images

Introduction

- Seismic Gas Hydrate Quantification by Cumulative Attributes (CATTs)
- Prime Recipient: Rock Solid Images, Houston, TX
- DE-FC26-06NT42961
- Project Manager: Frances Toro

Project Objective

Develop new methods to rapidly assess methane hydrate distribution and quantification using 3D seismic calibrated to well bore data. New methods should respond to hydrates in multiple thin beds as well as in thicker more massive sands.

ROCK SOLID images

Expected Benefits

Reliable gas hydrate characterization from seismic data is a key step to understanding and ultimately exploiting this untapped resource. Before hydrates can be considered a potential energy source for the US, we must know where they are most concentrated. These hydrate rich areas will be targeted first for possible development. If even the “easiest” 1% of this gas could be found and produced, it would more than double the current US proven reserves. Resulting benefits are;

- Faster hydrate resource high-grading from large seismic data volumes
- More accurate local calibration of 3D seismic to wellbore hydrate saturation
- Risk reduction in drilling through and producing from hydrate accumulations
- Improved data for climate models
- Helping to guide public policy with regard to climate change

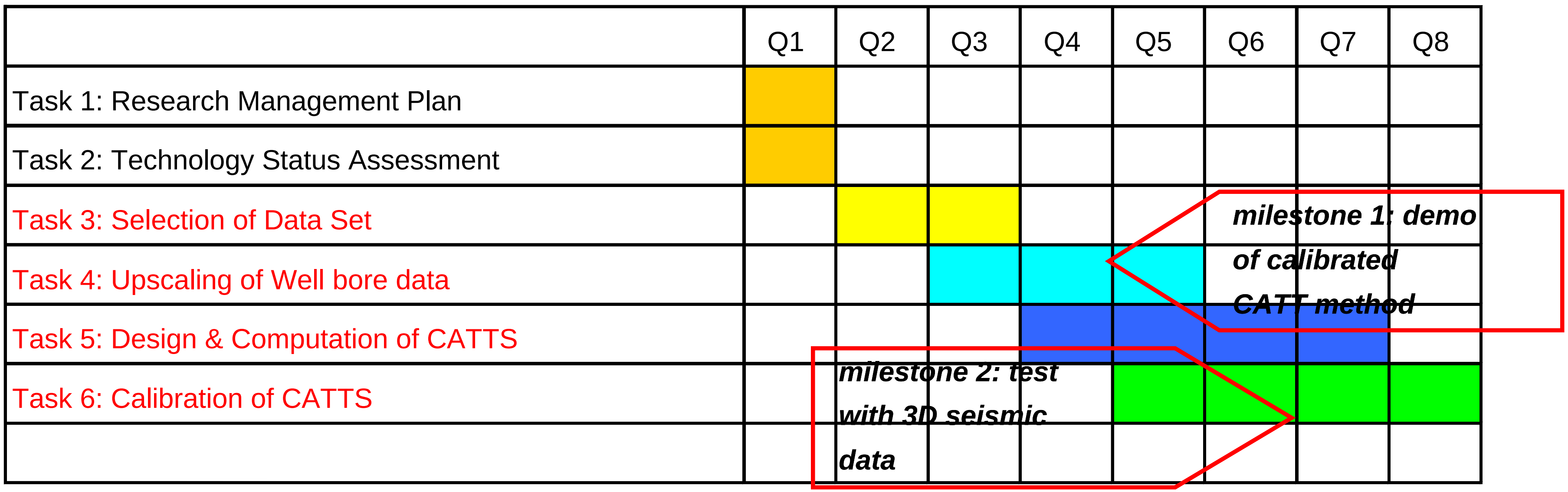
ROCK SOLID images

Technical Approach

- Develop new rock physics models that quantify key sand/silt textural parameters controlling both hydrate accumulation and seismic wave propagation.,
- Develop new upscaling routines that will allow calibration of 3D seismic attributes to core and well log data
- Develop and test a new class of seismic attributes called Cumulative Attributes (CATTs)
- Select physically relevant combinations of conventional attributes through forward modeling and rock physics. These conventional attributes will be converted to CATTs.
- Apply deterministic and statistical methods to capture the complex relationships among the attributes and the reservoir properties for each data set. Seismic attenuation will be important since it has physical links to methane hydrate concentration.
- Produce 3D images of gas hydrate distribution from existing 3D seismic surveys. All methods will be thoroughly tested with field data

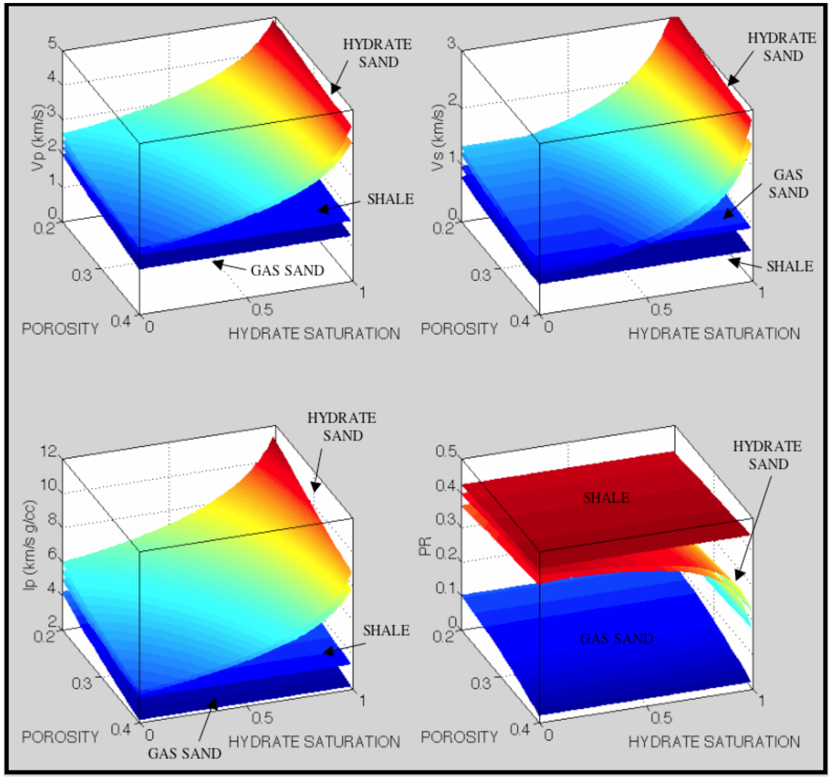
ROCK SOLID images

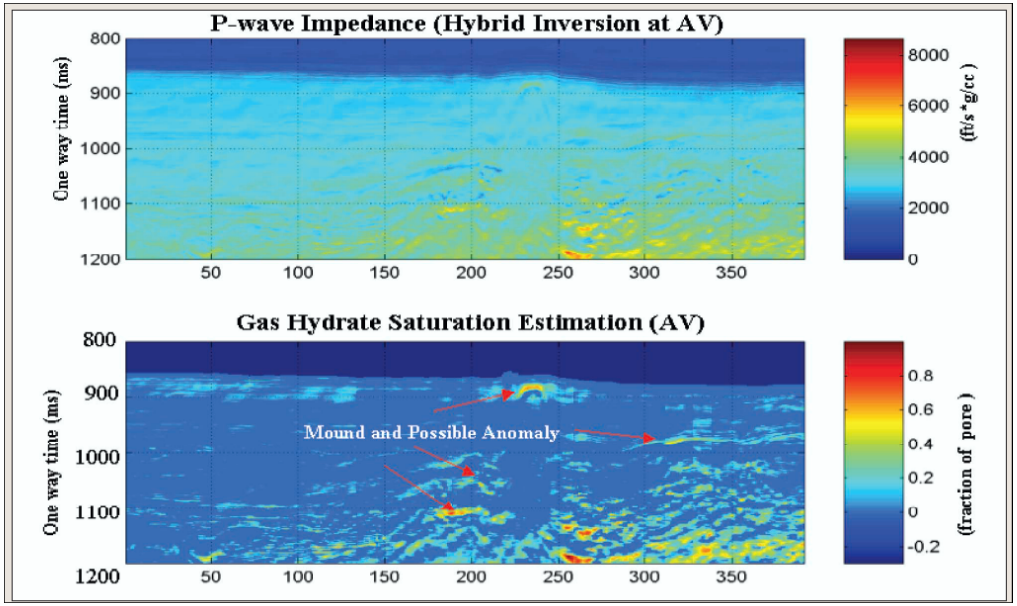
Tasks, Timing, Milestones



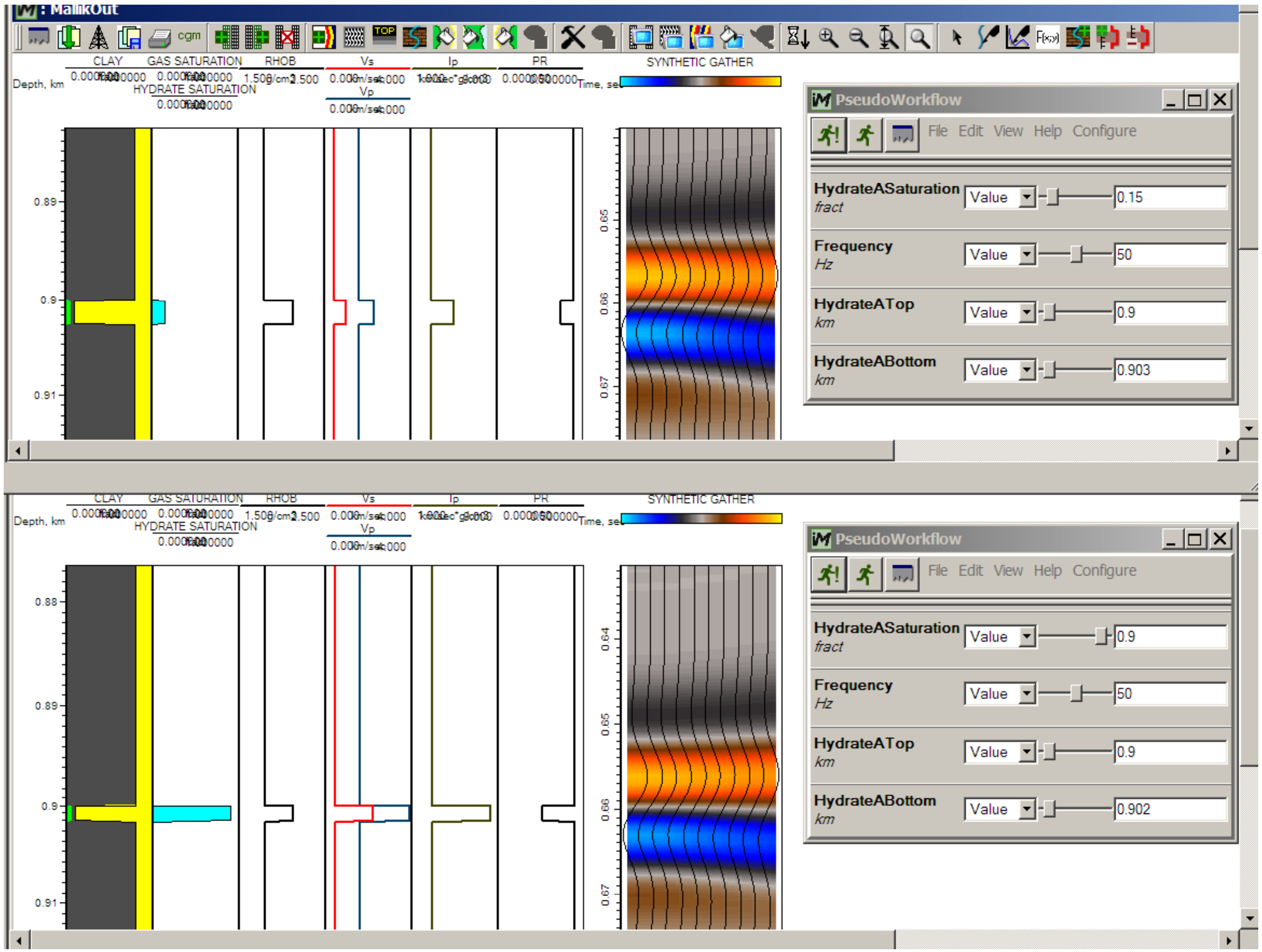
Background

- Hydrates have very distinctive rock physics behavior
- Most previous work has been based on conventional AI inversion with empirical transform to hydrate saturation
- Problem is this does not work well when hydrates occupy multiple thin zones.





Dai, J., Xu, H., Shyder, F., and Dutta, N.., 2004

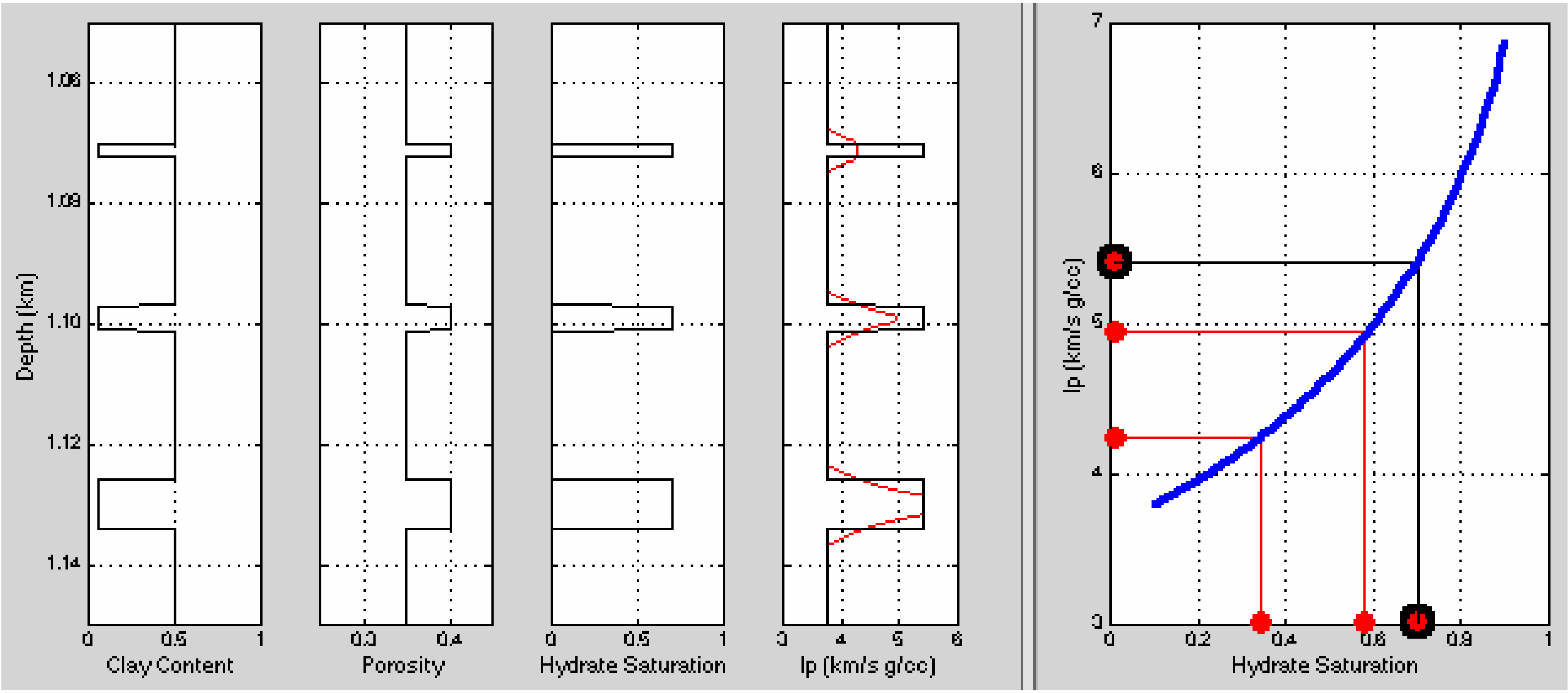


Synthetic gathers at two pseudo-wells that sample a blocky methane hydrate reservoir. Top – the thickness of the reservoir is 3 m while hydrate saturation is 0.15. Bottom – the thickness of the reservoir is 2 m while hydrate saturation is 0.9. All other parameters of the two pseudo-wells are identical.

Task 3: Selection of Dataset

- Gulf of Mexico JIP
  - Not much hydrate accumulation in Atwater Valley
  - Data owned by Schlumberger and not available to RSI
- Nankai Trough, Japan
  - All data proprietary to JOGMEC so far
- Hydrate Ridge, Oregon
  - Core data, well logs, and seismic. Have requested access.
- Cascadia Margin, BC, Canada
  - Core data, well logs, and 2D, “pseudo-3D” seismic. Will evaluate for suitability.
- Mallik, NW Territories, Canada
  - High hydrate concentrations
  - Good well log data
  - Reprocessed seismic from JOGMEC is adequate
  - Have all data in-house now, but waiting on permission to use from NRCan.
  - Best available option so far
- Milne Point, North Slope, Alaska
  - Log and seismic data believed to be good
  - Have contacted BP for access to data

Task 4: Upscaling of Wellbore Data for Seismic Calibration

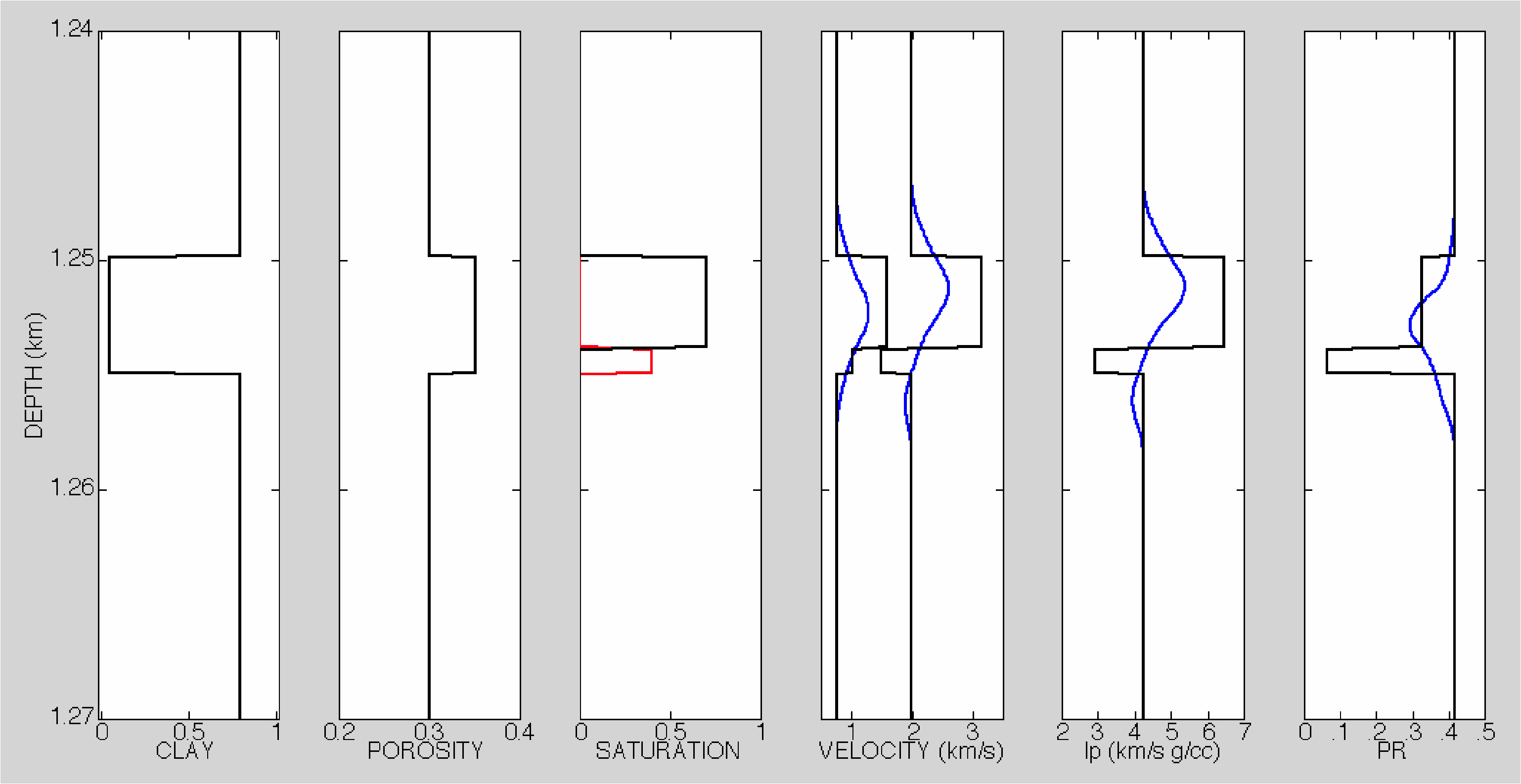


Earth model with three methane hydrate layers.
From left to right: clay content; porosity; hydrate saturation; and acoustic impedance.
The red curve is the Backus average of the log-scale impedance using a running 5-meter window.
The plot on the right shows model impedance versus hydrate saturation curve (blue) and the seismic-scale impedance and inferred hydrate saturation (red symbols).
The black symbols represent the log-scale impedance.

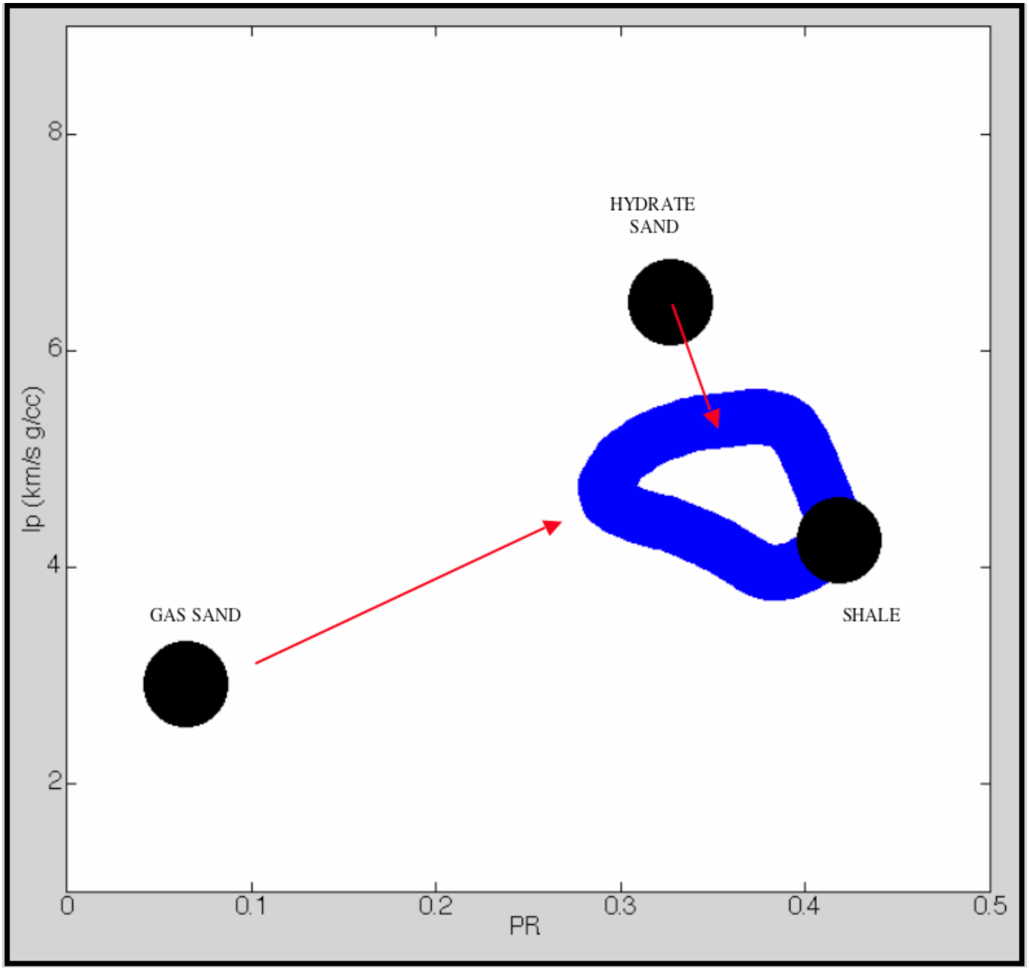
Low impedance at the seismic scale may represent low hydrate saturation in a thick layer or high saturation in thin layer.

ROCK SOLID images

▪ CAVEAT OF SEISMIC RESOLUTION



Pseudo well with methane hydrate. From left to right: clay content; total porosity; hydrate (black) and gas (red) saturation; P- and S-wave velocity; P-wave impedance; and Poisson's ratio. In the last three frames the black curves are for the original log data while the blue curves represent Backus-average upscaling.



Impedance versus Poisson's ratio from pseudo-log data shown in Figure 21. Black symbols indicate the positions of the three lithofacies, shale, hydrate sand, and gas sand at the log scale. Blue symbols are the cross-plot of the upscaled elastic properties. Red arrows show how the position of hydrate sand and gas sand move due to this upscaling.

Accumulated Hydrate Volume

$$V_{MH} = \int \phi(z) S_{MH}(z) dz = \int C_{MH}(z) dz,$$

Perfect CATT

$$C_M = \int [M_B^{-1}(z) - M^{-1}(z)] dz.$$

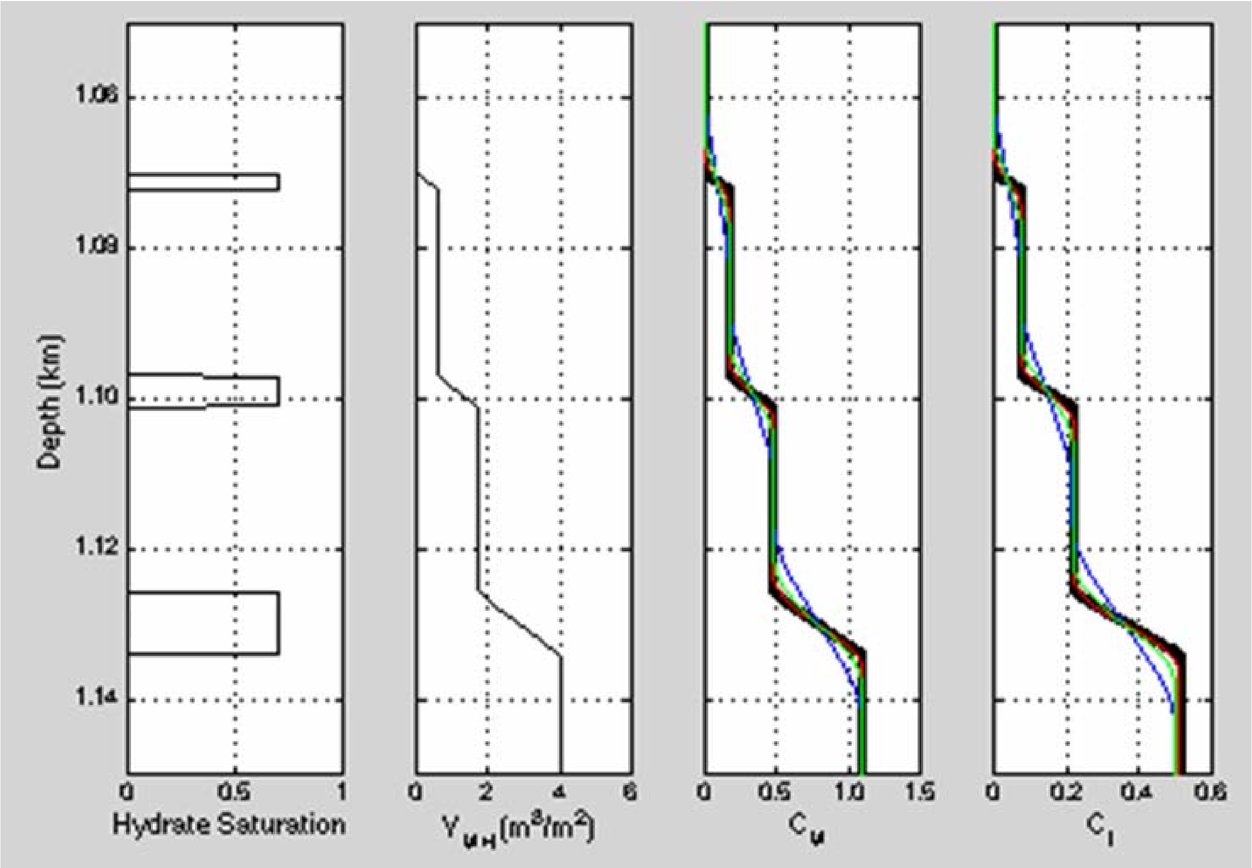
Seismic CATT

$$C_I = \int [I_{pB}^{-2}(z) - I_p^{-2}(z)] dz,$$

ROCK SOLID images

Task 5: Design and Computation of CATTs for Hydrates

- What if we want to quantify total hydrate volume?



hydrate saturation

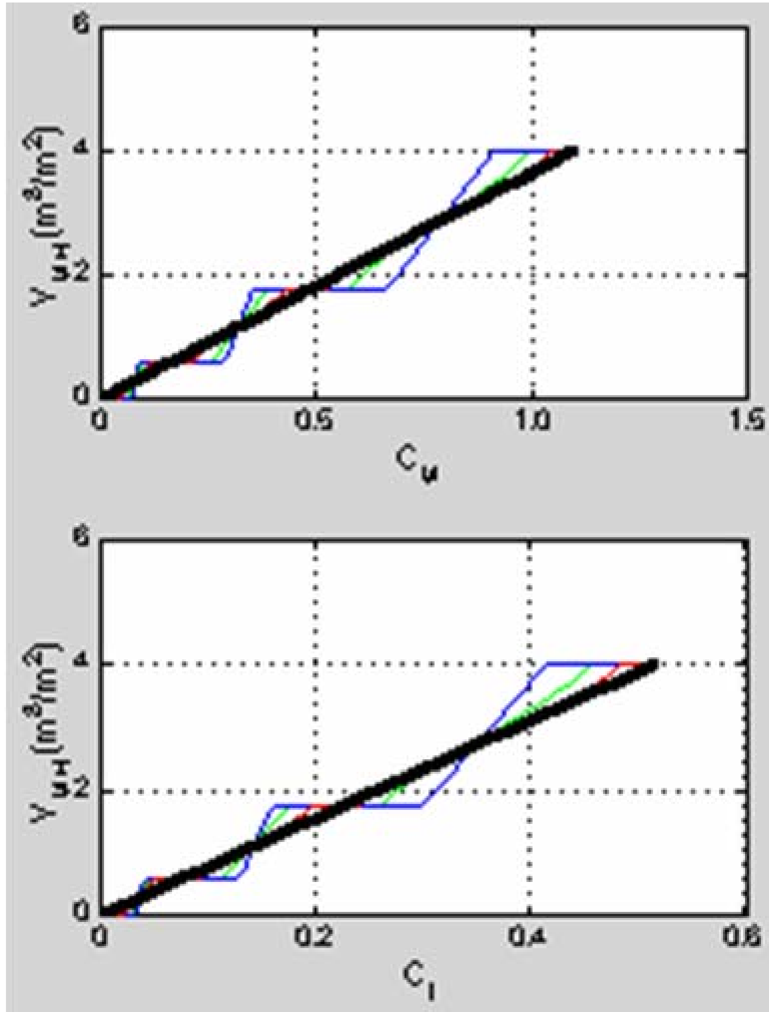
accumulated hydrate volume

integral of anomaly of 1/M (comp. modulus)

integral of anomaly of 1/ AI^2

5-meter (red), 10-meter (green), and 20-meter (blue) running window

Task 6: Calibration of CATTS for Hydrate Quantification



accumulated hydrate volume vs. integrated inverse modulus anomaly

accumulated hydrate volume vs. integrated inverse AI anomaly

5-meter (red), 10-meter (green), and 20-meter (blue) running window

ROCK SOLID images

Deliverables

Periodic, topical, and final reports will be delivered in accordance with the requirements of this project. In addition we anticipate issuing status reports on the following technical topics:

- Task 3: Selection of Seismic Data Set
- Task 4: Rock Physics and Upscaling of Wellbore Data for Seismic Calibration
- Task 5: Design and Computation of CATTS for Hydrates
- Task 6: Calibration of CATTS for Hydrate High Grading

Risks

Technical risks that must be overcome include the development of;

- Obtaining suitable data set (seismic, logs, core)
- Suitable rock physics models to inter-relate porosity, lithology, hydrate content, and seismic response.
- Upscaling methods to relate fine-scale core and well log data to coarse scale seismic and well test data.
- Appropriate cumulative attributes that will mimic hydrate volumes and work in a wide range of geographic regions.

The degree of success in this project will be defined by the comparison of computed hydrate volume from seismic with measured hydrate occurrence in “blind” well locations.

Contributors

- Joel Walls, PI
- Jack Dvorkin
- M.T. Taner
- Scott Singleton
- Naum Derzhi
- Gary Mavko, consultant
- Sven Trietel, consultant

Budget Periods

Start: Oct 1, 2006 **Sept 30, 2007**

Section D - Forecasted Cash Needs					
	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th quarter
13. Federal	$349,088	$67,025	$104,467	$92,976	$84,619
14. Non-Federal	$87,272	$16,756	$26,117	$23,244	$21,155
15. Total (sum of lines 13 and 14)	$436,360	$83,782	$130,584	$116,221	$105,773

Oct 1, 2007 **End: Sept 30, 2008**

Section D - Forecasted Cash Needs					
	Total for 2nd Year	1st Quarter	2nd Quarter	3rd Quarter	4th quarter
13. Federal	$609,792	$217,987	$221,019	$84,423	$86,364
14. Non-Federal	$152,448	$54,497	$55,255	$21,106	$21,591
15. Total (sum of lines 13 and 14)	$762,241	$272,483	$276,274	$105,528	$107,955

Two-Year Total

Section A - Budget Summary						
Grant Program Function or Activity	Catalog of Federal Domestic Assistance Number	Estimated Unobligated Funds		New or Revised Budget		
		Federal	Non-Federal	Federal	Non-Federal	Total
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1. Fossil Energy R&D	81.089			$958,880	$239,720	$1,198,600
2.						$0
3.						$0
4.						$0
5. Totals		$0	$0	$958,880	$239,720	$1,198,600

ROCK SOLID images

Commercialization

- Software (iMOSS)
  - Hydrate rock physics modules
  - Cumulative Attributes
  - Log-Seismic calibration modules
- Services
  - Well-based rock physics
  - Synthetic seismic and attributes
  - Integration with filed seismic
  - Inversion of 3D seismic for hydrate volume
  - Risk assessment and prospect high-grading