Electrical Resistivity Investigation of Gas Hydrate Distribution in Mississippi Canyon Block 118, Gulf of Mexico

Prime Recipient
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Department of Geology
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NETL Project Manager
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Objectives

Project Objectives

- Evaluate direct-current electrical resistivity (DCR) method for use in hydrate exploration and production.
- Characterize the sub-bottom distribution of hydrate within Mississippi Canyon Block 118, Gulf of Mexico (MC 118).
- Monitor change in hydrate concentration/distribution over time.

Phase Objectives

- **Phase 1**
  - Reconfigure commercial DCR system for ocean-bottom deployment.
  - Evaluate DCR method in survey mode, using bottom-towed configuration.
- **Phase 2**
  - Reconfigure DCR system for fixed, autonomous seafloor operation.
  - Evaluate DCR method in long-term monitoring mode.

Expected Benefits

- **Low-cost evaluation of potentially critical technology.**
- **Expandable to commercial-scale, high-spatial resolution, 3D/4D mapping of hydrate concentration.**
- **Contribute to fundamental understanding of thermal-gas hydrate systems.**

Project Organization

Baylor University, Waco, Texas (John Dunbar)

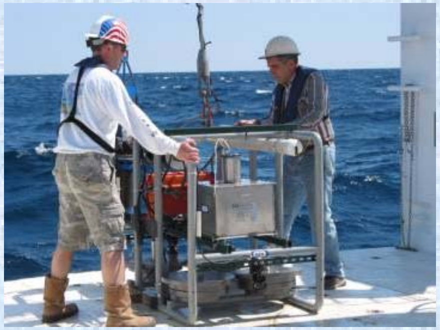
Shear wave seismology, marine seismic acquisition, sub-bottom profiling and electrical methods.

Geophysical data acquisition, processing, and interpretation.
Federal funds $157,256.

Advanced Geosciences, Inc., Austin, Texas (Mats Lagmanson)

Commercial DCR systems for engineering, mining, and environmental applications.

Electronic components for DCR system.
Federal funds $58,330.



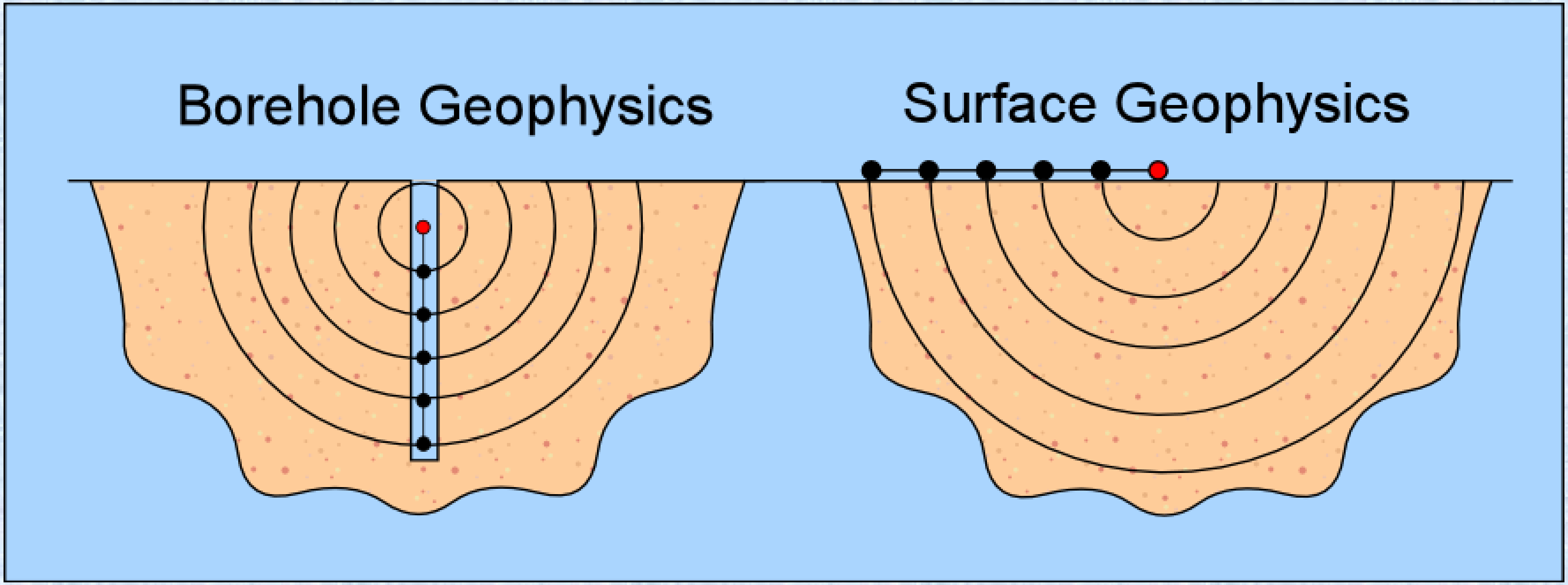
Specialty Devices, Inc., Wylie, Texas (Paul Higley)

Electrical/ocean engineering, marine acoustics, deep-sea ROVs.

Assembly of ocean-bottom DCR system, field deployment.
Federal funds $62,500.

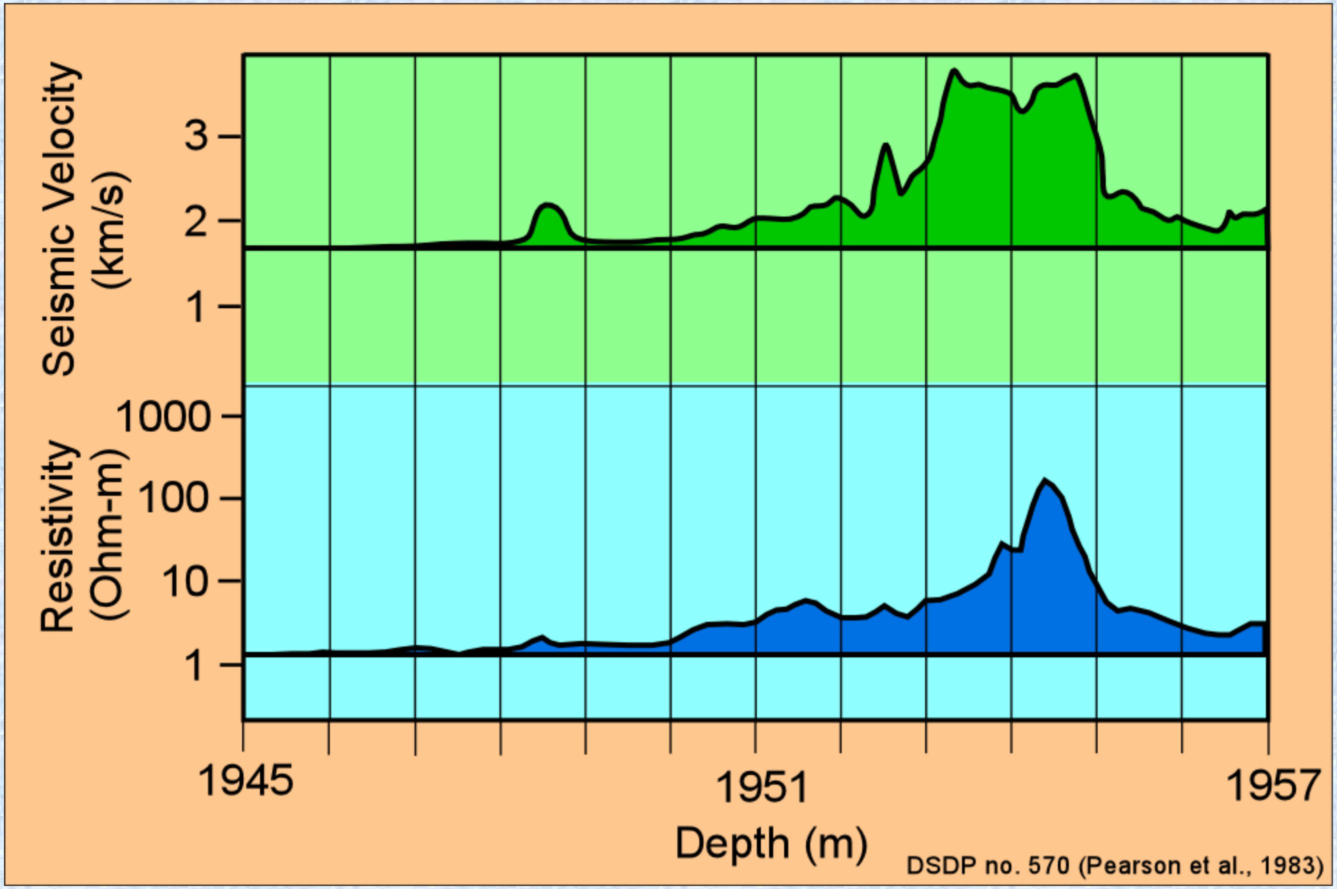
Background

Active-Source Geophysical Methods



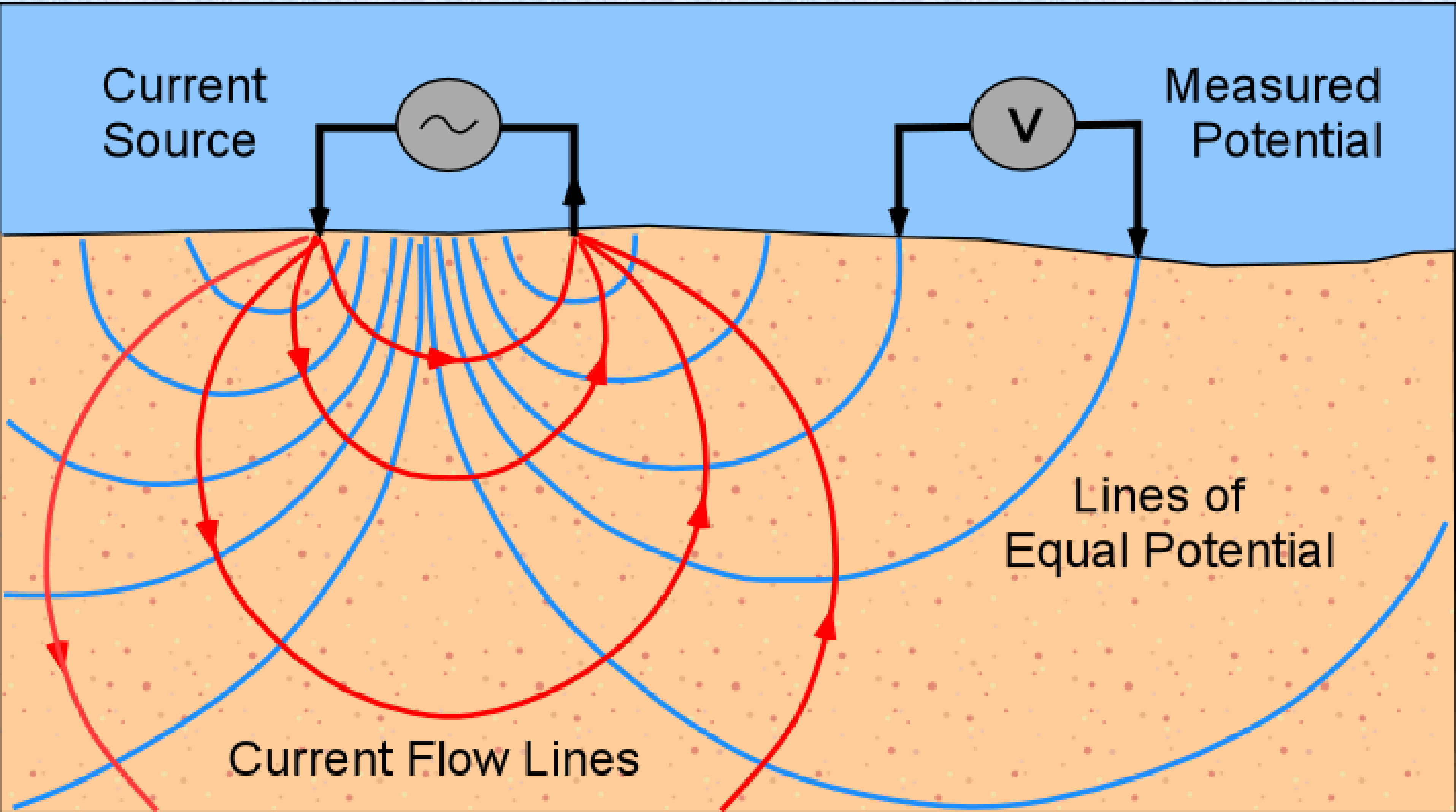
Sonic Logging	**=>**	**Reflection/Refraction Seismology**
Induction Logging	**=>**	**Controlled Source EM**
Resistivity Logging	**=>**	**Direct Current Resistivity (DCR)**

Why Use Electrical Methods to Explore for Hydrates?



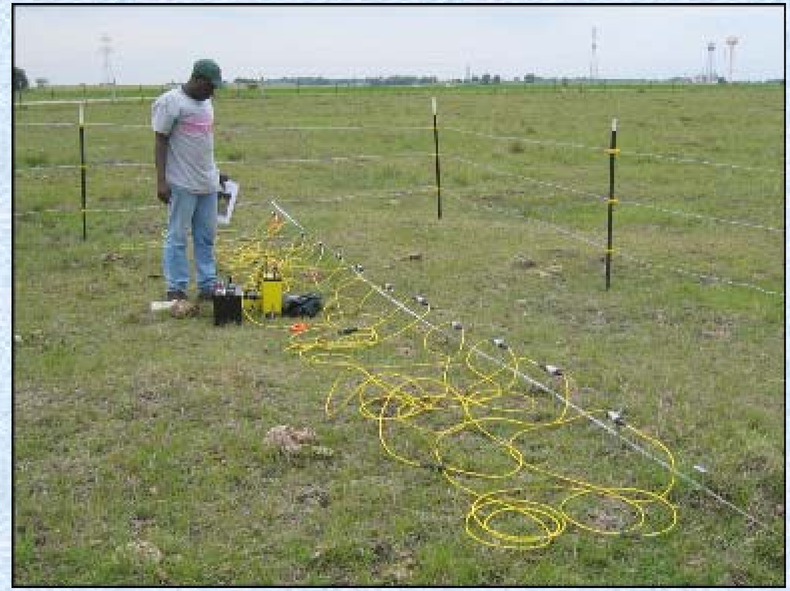
- **Seismic velocity is sensitive to the presence of hydrate at low saturation, but is less sensitive to changes at high saturation.**
- **Resistivity changes progressively with the degree of saturation (Archie's law).**

Direct Current Resistivity Method (DCR)

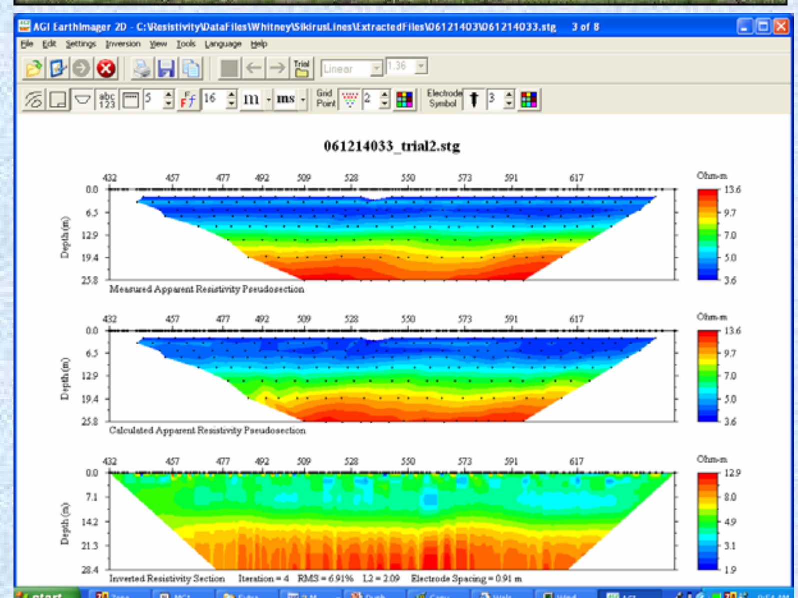


Modern DCR Methods

- **Multi-electrode acquisition**
  - Computer controlled
  - **Tens to hundreds of electrodes**
  - **8 channels**
  - **2D and 3D**
  - **Land and shallow marine**
  - **Depths ≤ 500 m**

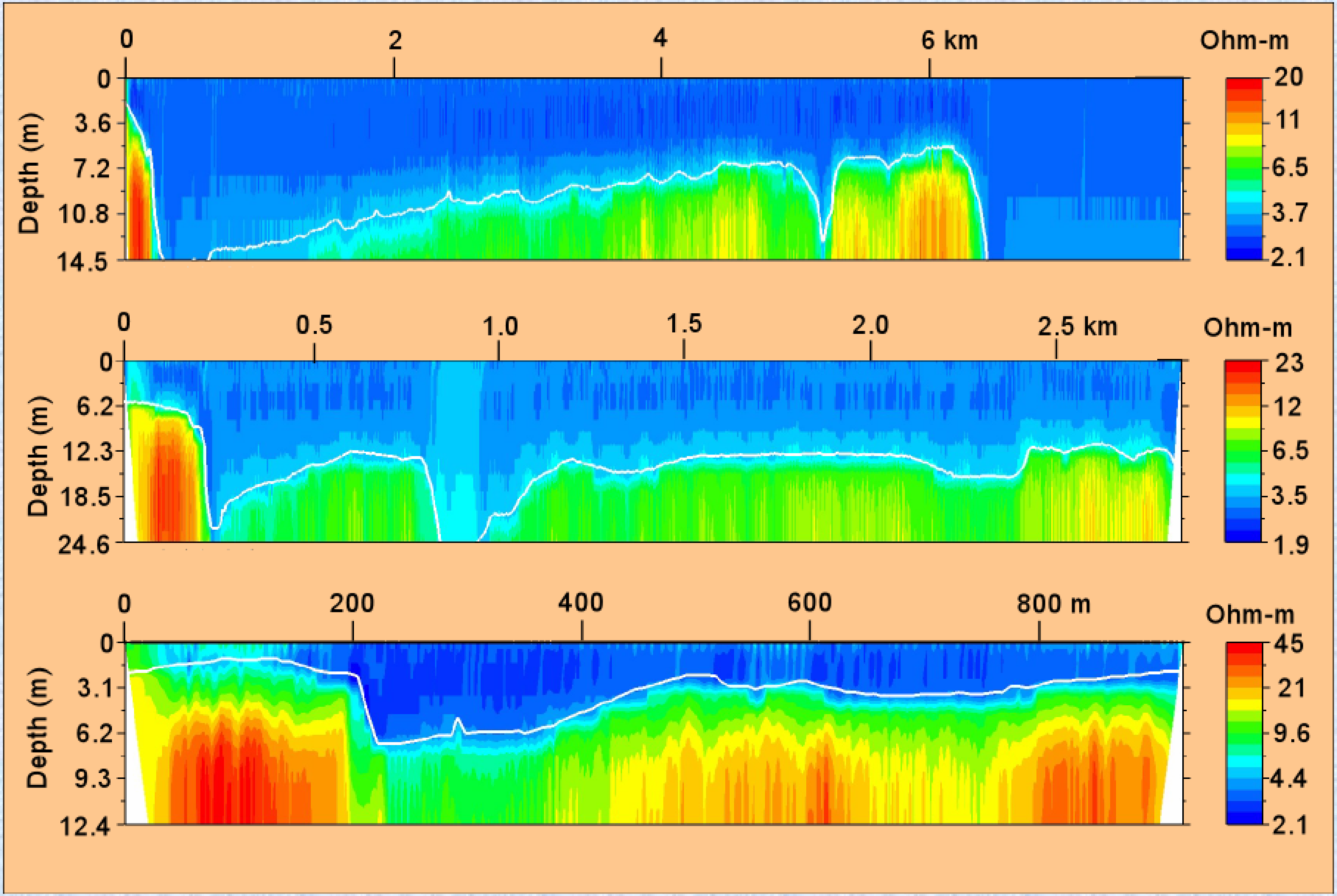


- **Tomographic inversion**
  - **Poisson's - equation based**
  - **Automated**
  - **2D and full 3D***
  - **PC based***
  - **Time-lapse**



Shallow Marine DCR System,
Lake Whitney, Texas

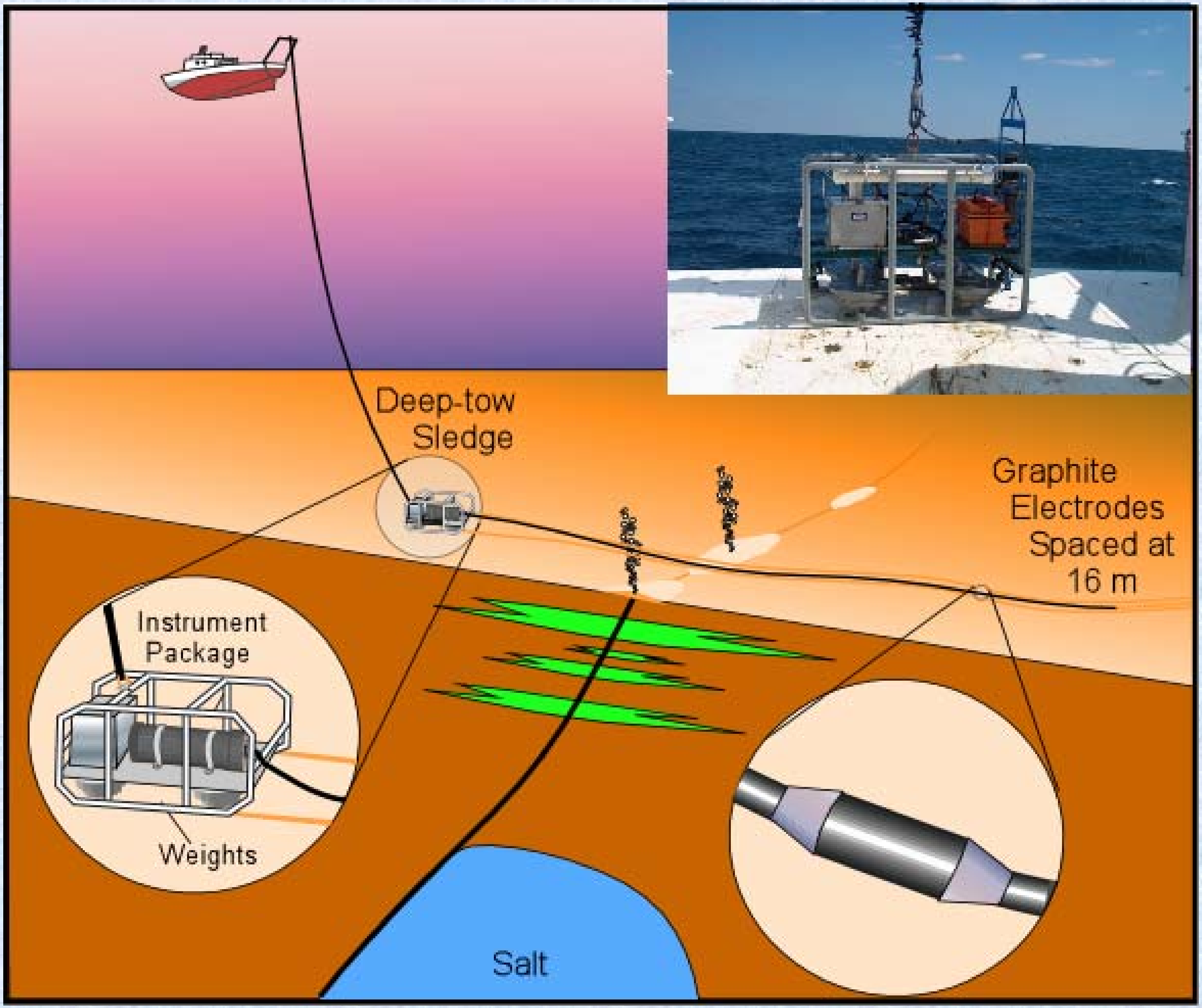
Example Inverted DCR Sections from Lake Whitney, Texas



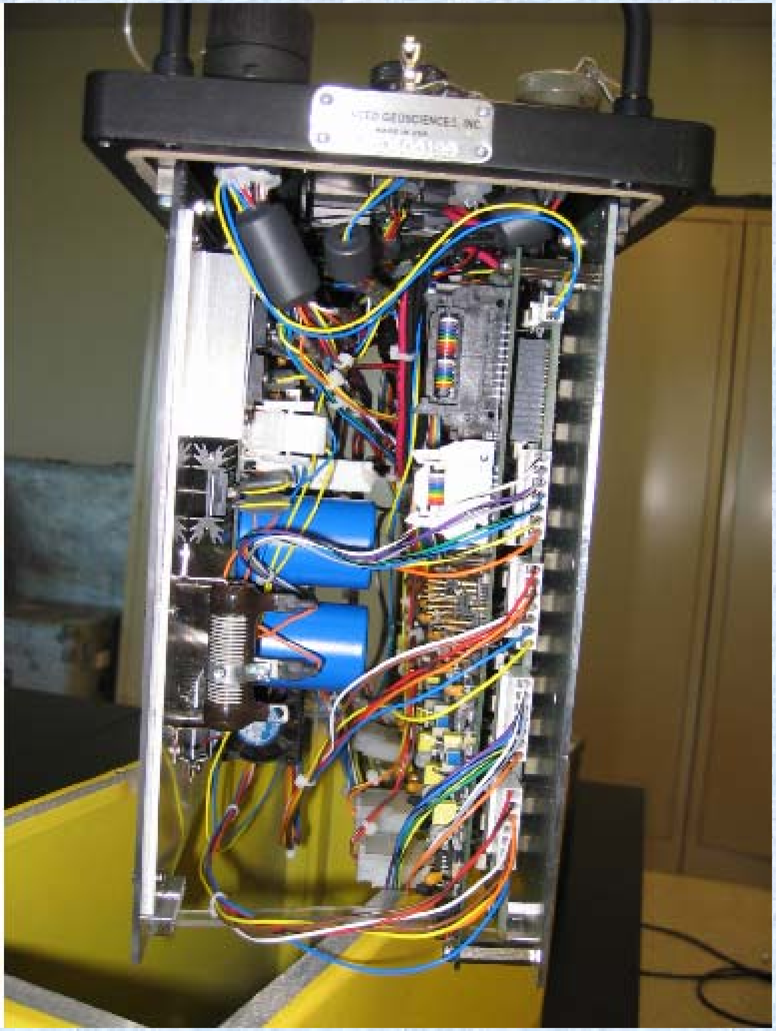
Phase 1: Evaluation for use in Reconnaissance Surveys for Deep-Sea Hydrates

- Task 1.1 – 1.4: Construction prototype seafloor DCR system.
  - Problem: Adaptation of commercial, shallow-marine DCR system for deep-sea application.
  - Risk: Unforeseen technical problems.
  - Critical Milestone: System complete by end 9/2007.
- Tasks 1.5 - 1.7: Survey of region of known gas hydrate occurrence.
  - Problem: Avoiding seafloor obstacles, while achieving adequate spatial coverage within target area.
  - Risk: Equipment or logistical failure.
  - Critical Milestone: Complete survey by end 12/2007.
  - Deliverables for Phase 1:

Bottom-Tow DCR System



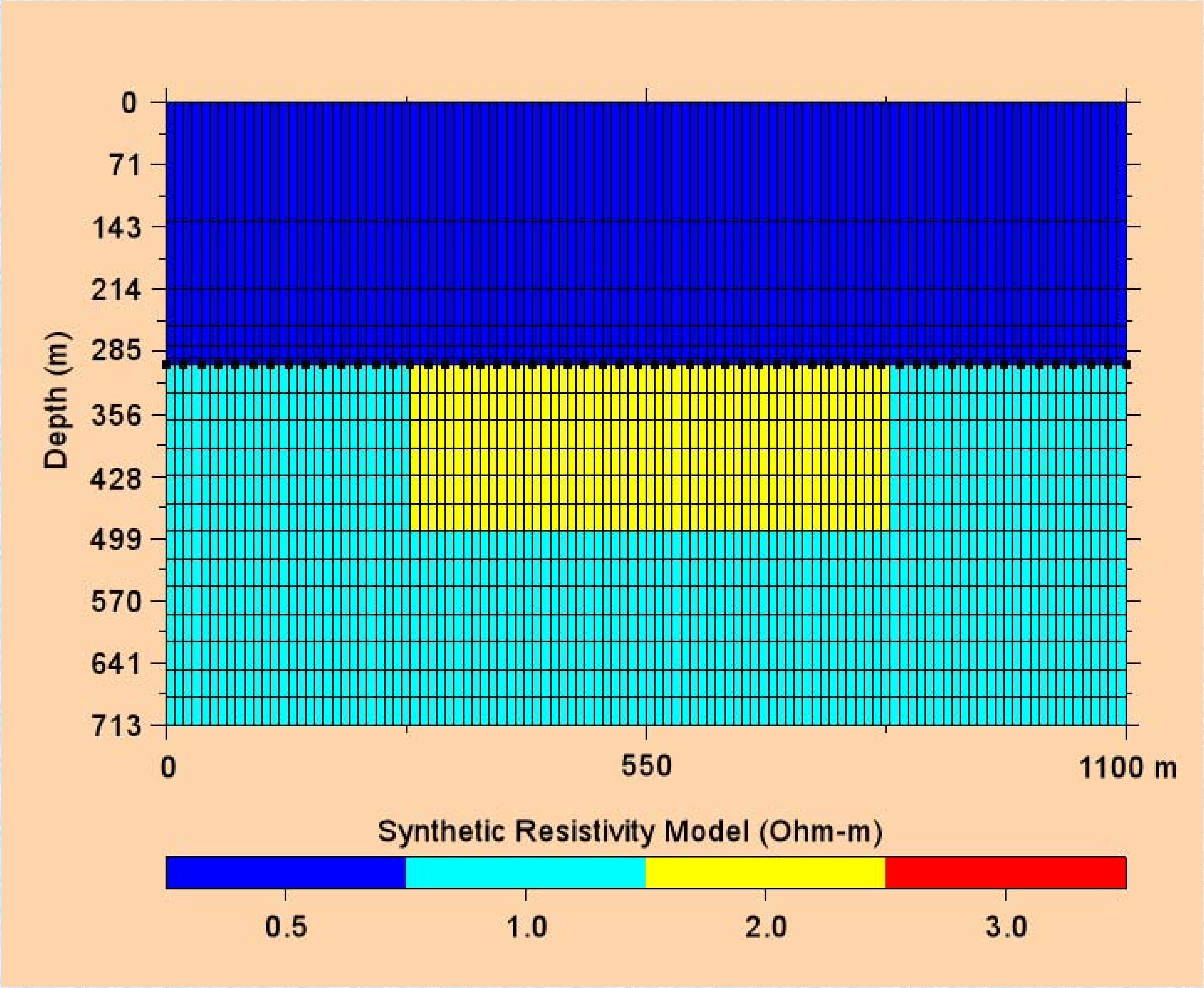
Interior of AGI, SuperSting, DCR Control Module



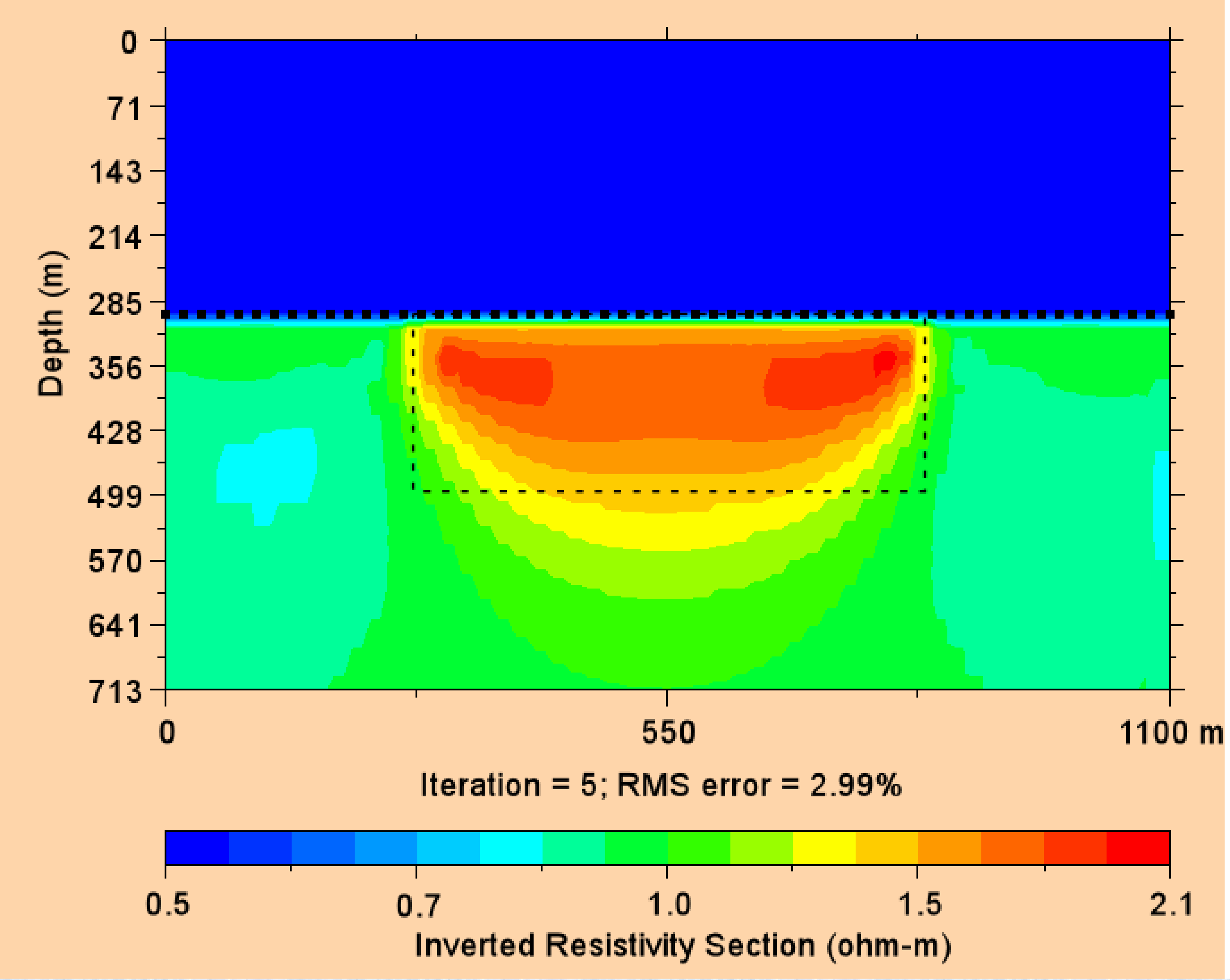
Instrument Pressure Housing Design

Bellamare, Inc., La Jolla, California

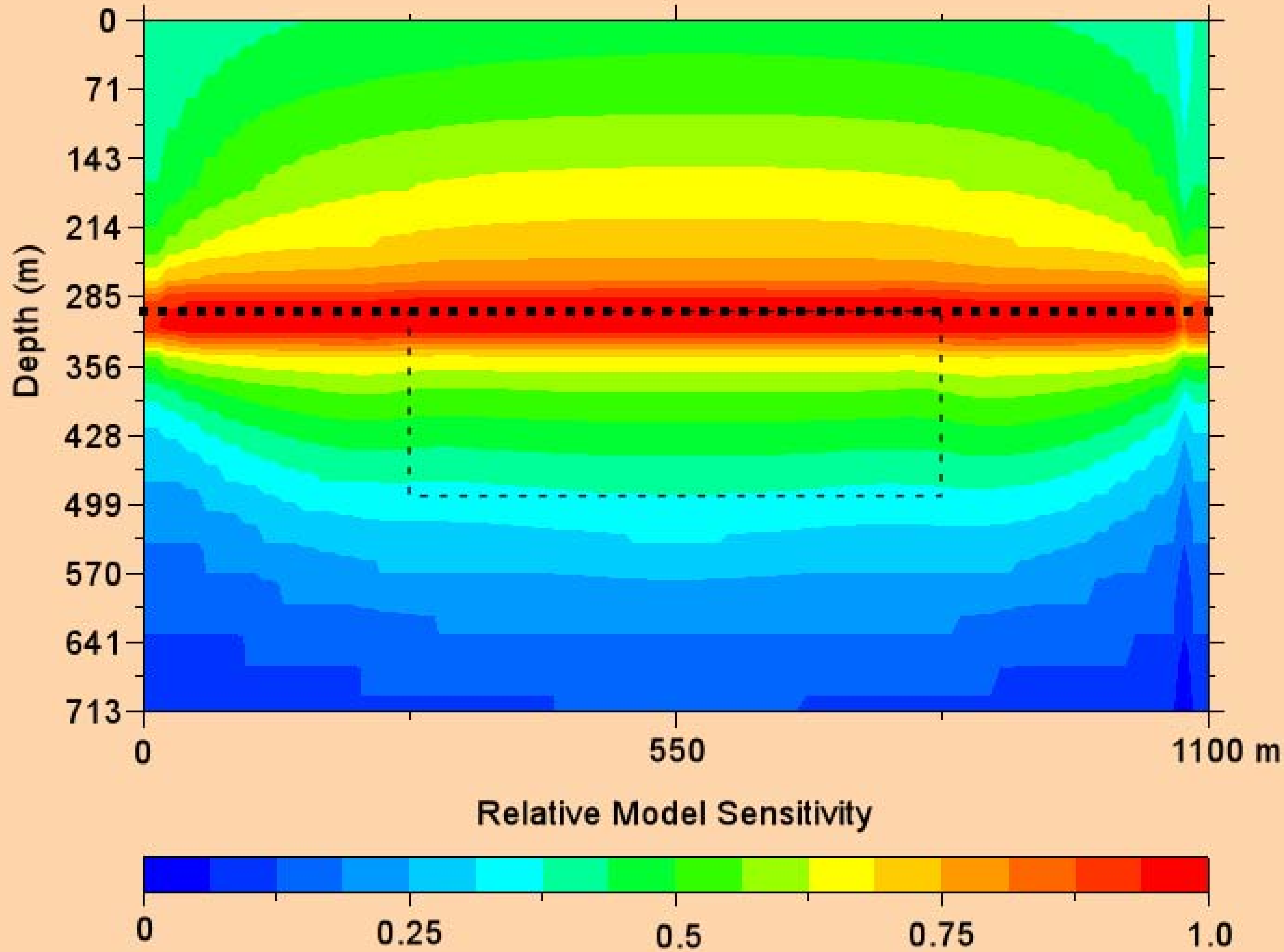
Synthetic Forward Model
200 m thick Hydrate, 56-electrode, 1100 m Array

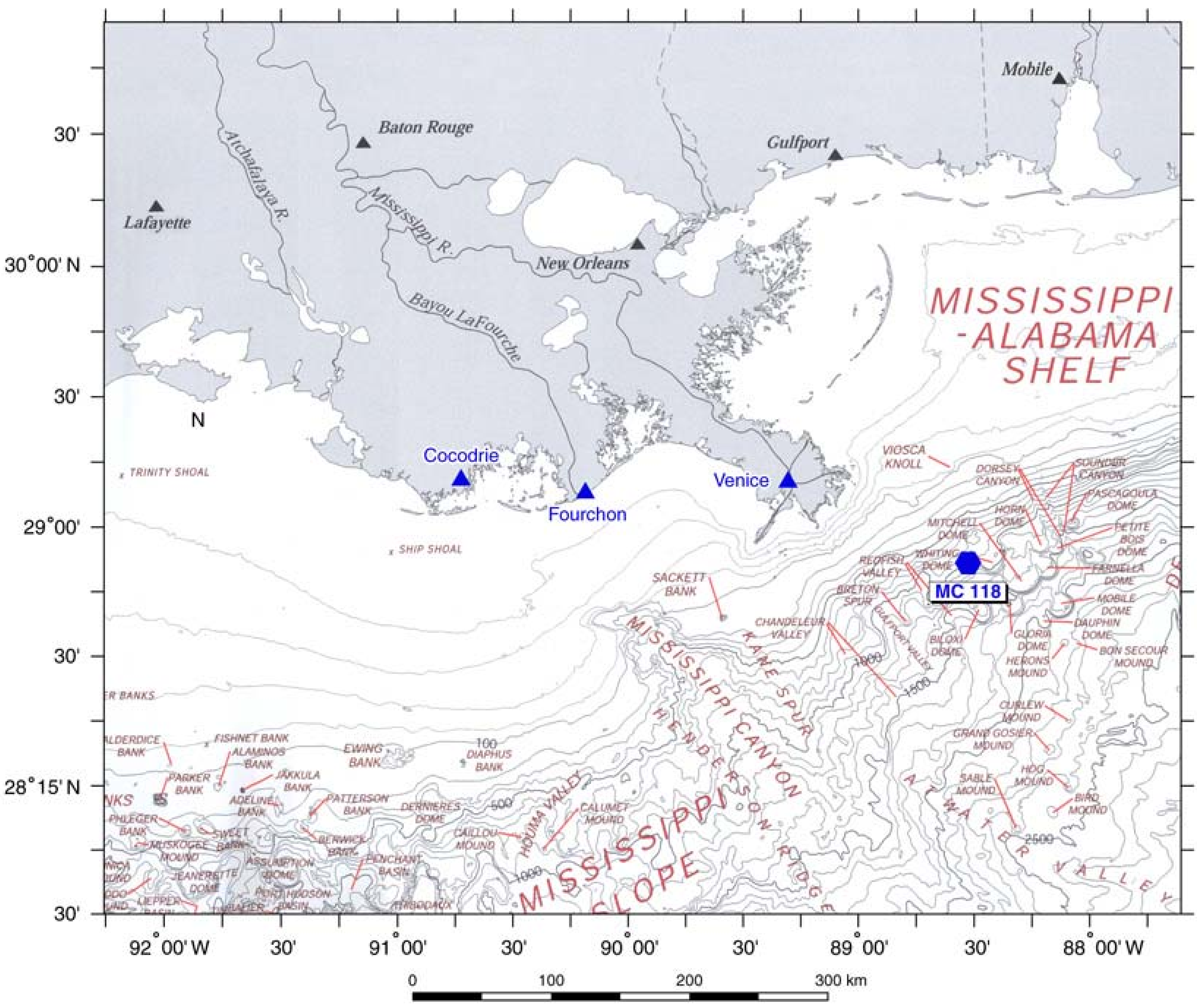


Inverted Resistivity Section from Synthetic Model
1100 m Array



Relative Sensitivity Section
1100 m Array





Mobile
Baton Rouge
Gulfport
Atchafalaya R.
Mississippi R.
Lafayette
New Orleans
Bayou LaFourche
MISSISSIPPI -ALABAMA SHELF
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Cocodrie
Venice
Fourchon
TRINITY SHOAL
SHIP SHOAL
VIOSCA KNOLL
DORSEY CANYON
SOUNDER CANYON
PASCAGOULA DOME
HORN DOME
MITCHELL DOME
PETITE BOIS DOME
WHITING DOME
REDFISH VALLEY
FARNELLA DOME
MC 118
SACKETT BANK
BRETON SPUR
MOBILE DOME
CHANDELEUR VALLEY
BILOXI DOME
GLORIA DOME
DAUPHIN DOME
BON SECOUR MOUND
HERONS MOUND
MISSISSIPPI CANYON
KANE SPUR
CURLEW MOUND
GRAND GOSIER MOUND
HENDERSON RIDGE
ATWATER VALLEY
SABLE MOUND
HOG MOUND
BIRD MOUND
FISHNET BANK
ALAMINOS BANK
EWING BANK
DIAPHUS BANK
PARKER BANK
JAKKULA BANK
ADELINE BANK
PATTERSON BANK
DERNIERES DOME
CALUMET MOUND
HOUMA VALLEY
CAILLOU MOUND
PHLEGER BANK
SWEET BANK
BERWICK BANK
ASSUMPTION DOME
PENCHANT BASIN
JEANERETTE DOME
PORT HUDSON BASIN
THIBODAUX
MISSISSIPPI SLOPE
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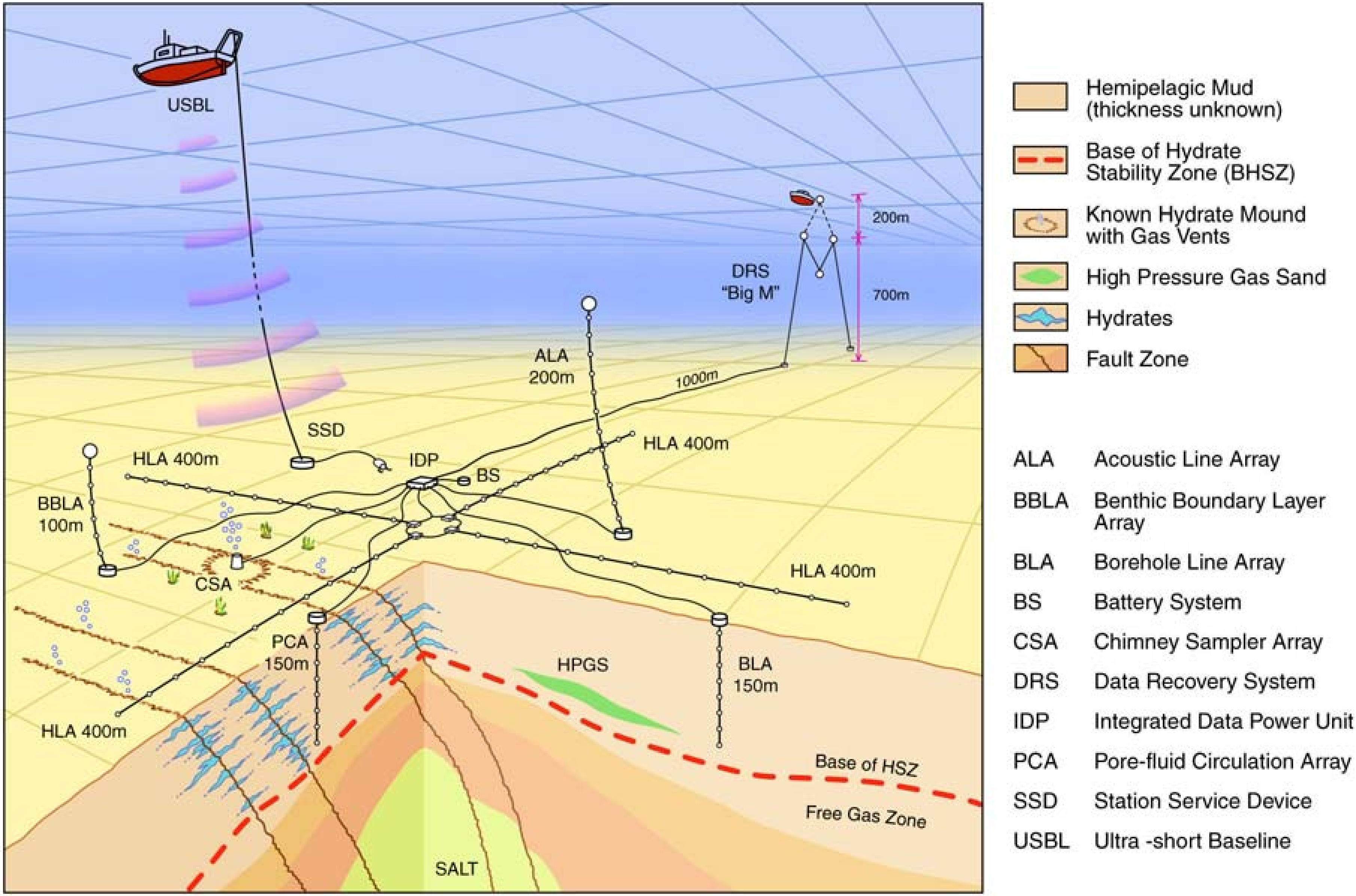
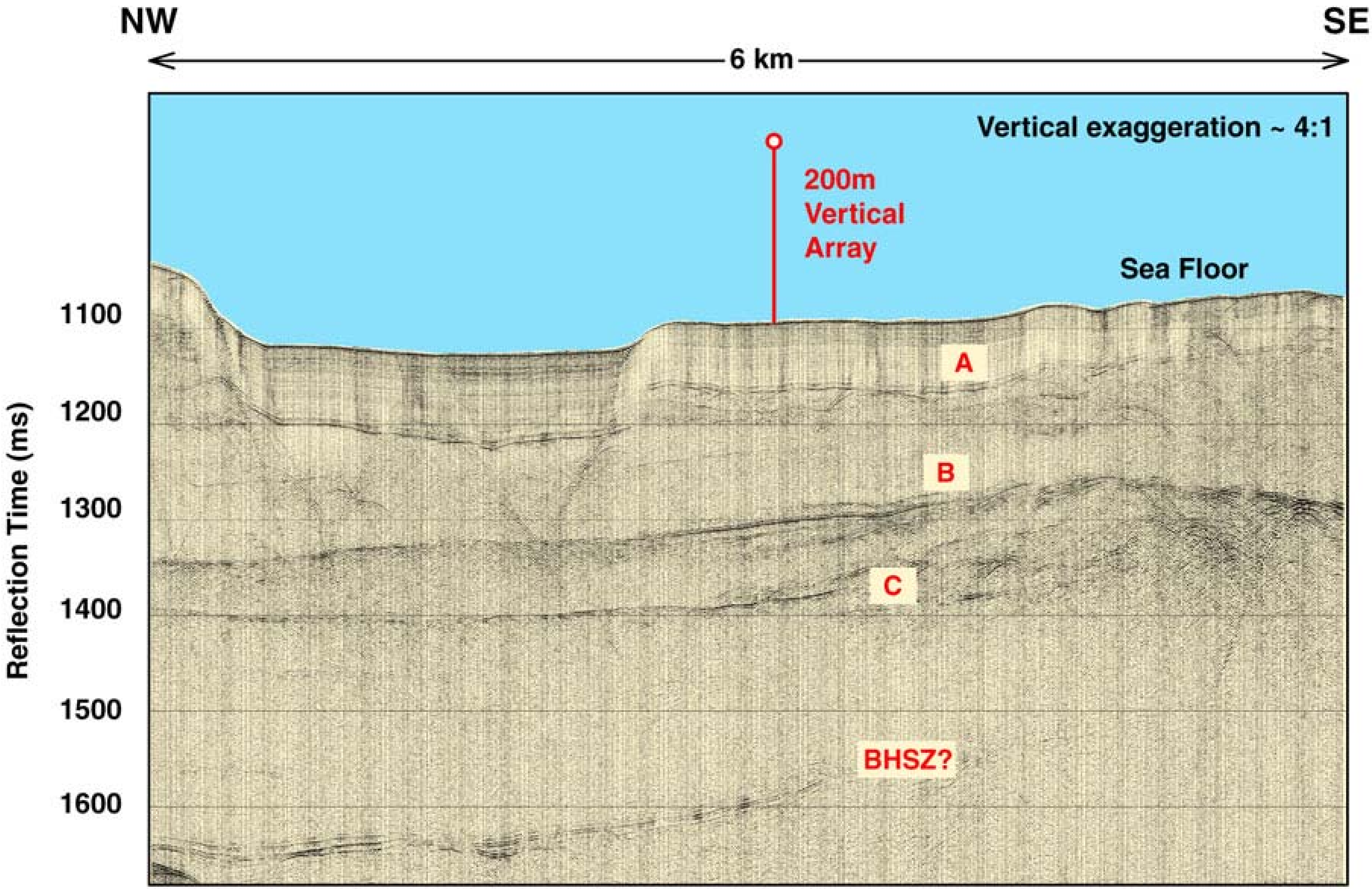
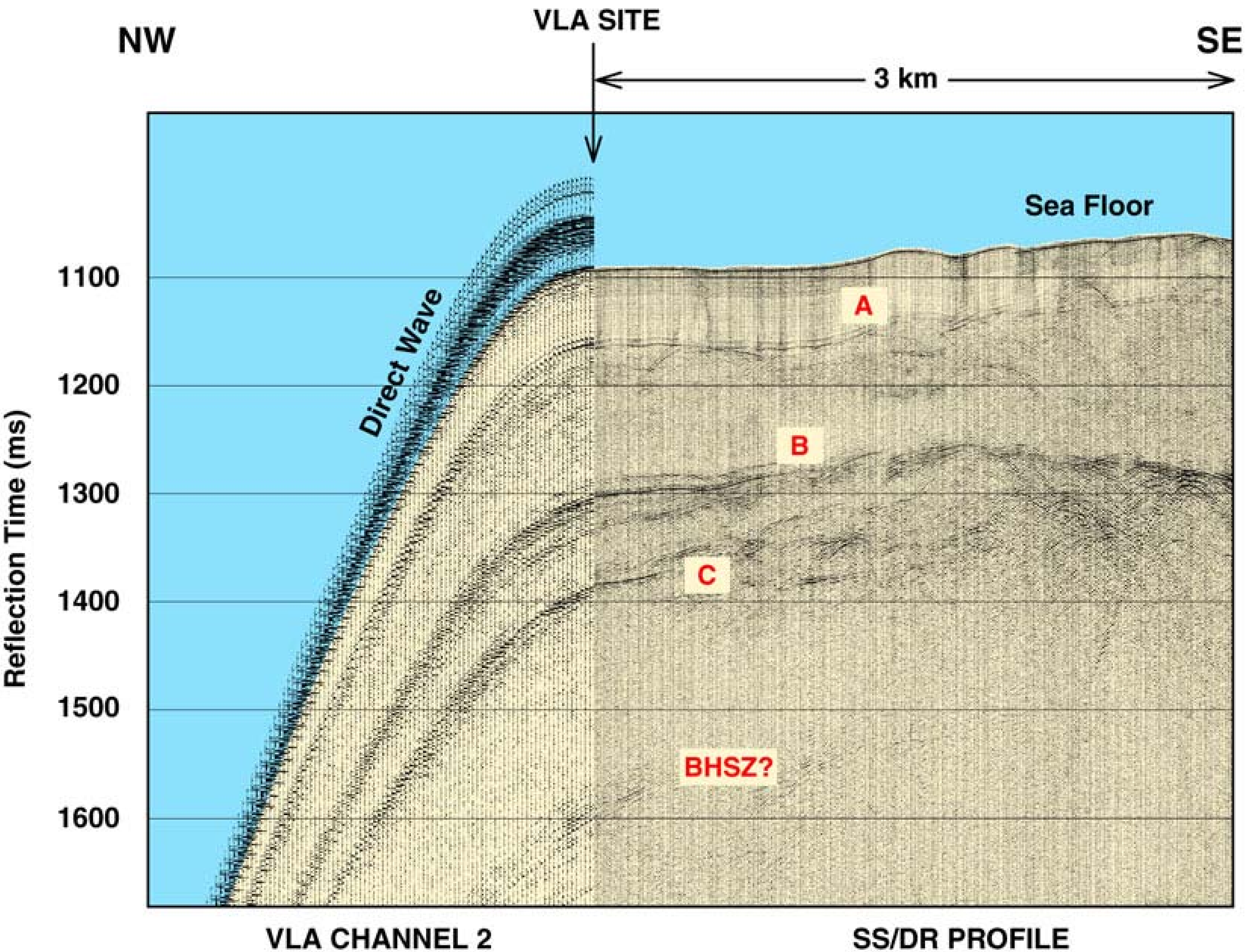


Gas Hydrate Sea Floor Observatory - Mississippi Canyon Block 118

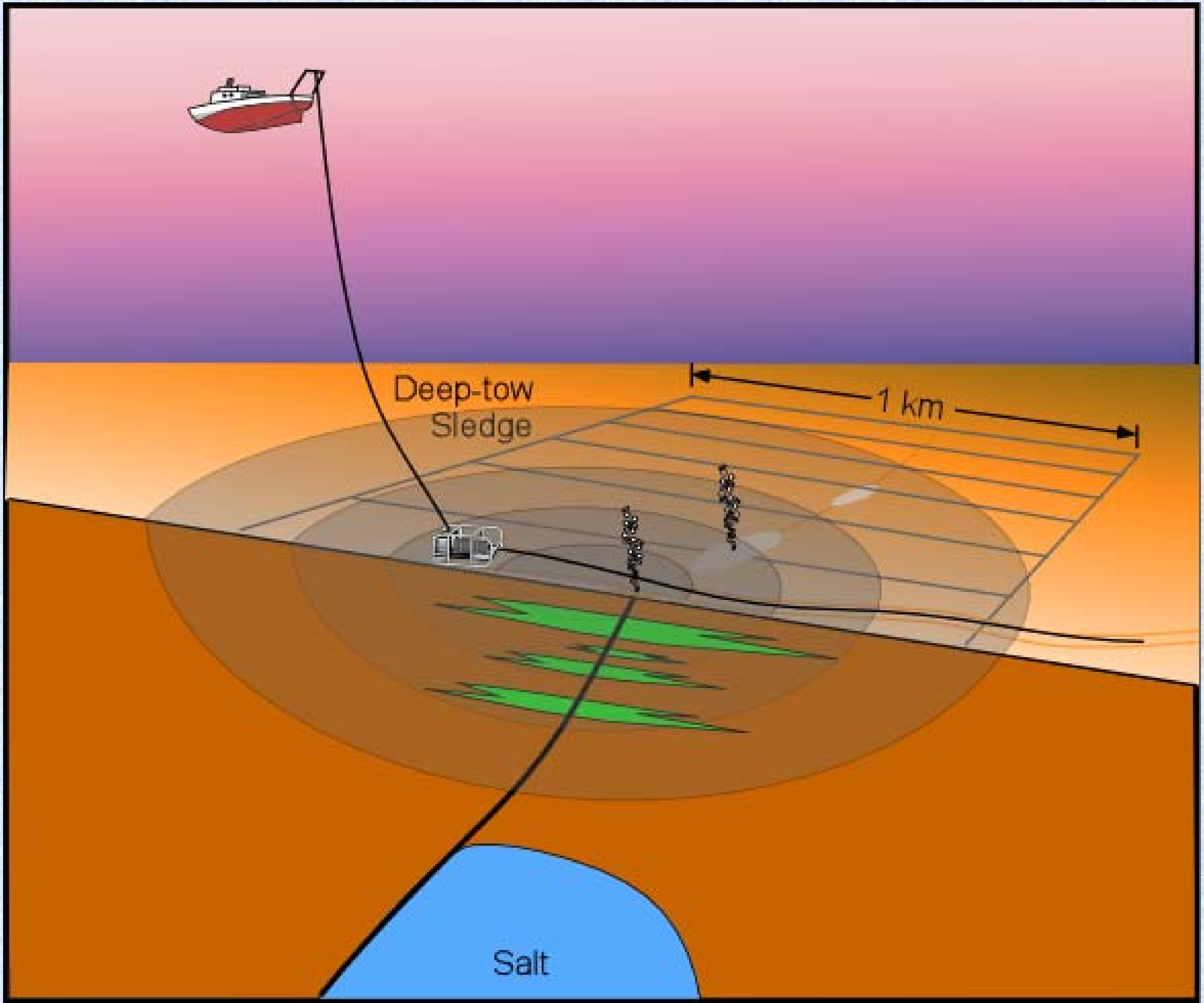


Zero-offset Reflection Profile over Vertical Array Site



Comparison of VLA Data and Profile Data

Reconnaissance DCR Survey of MC 118

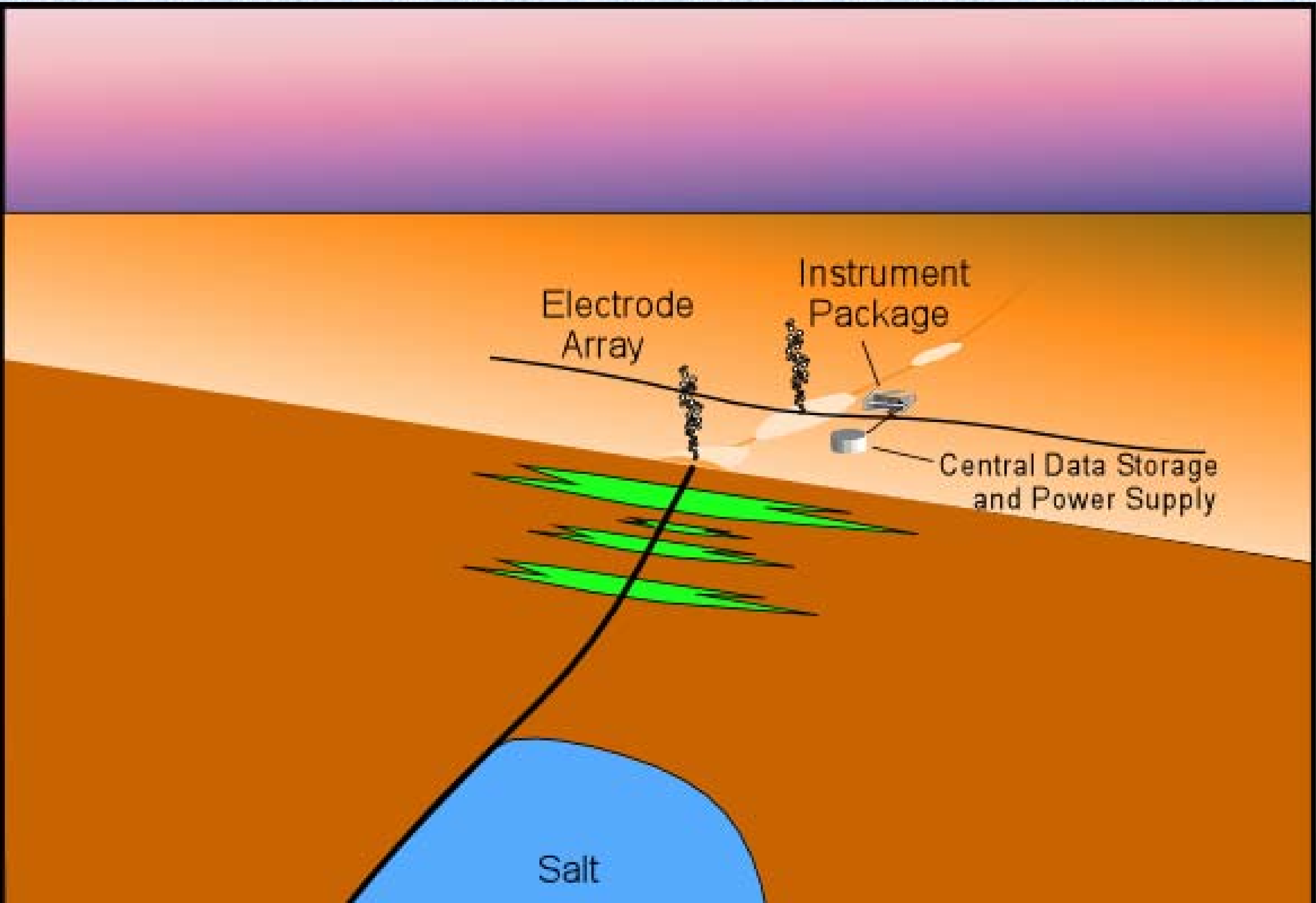


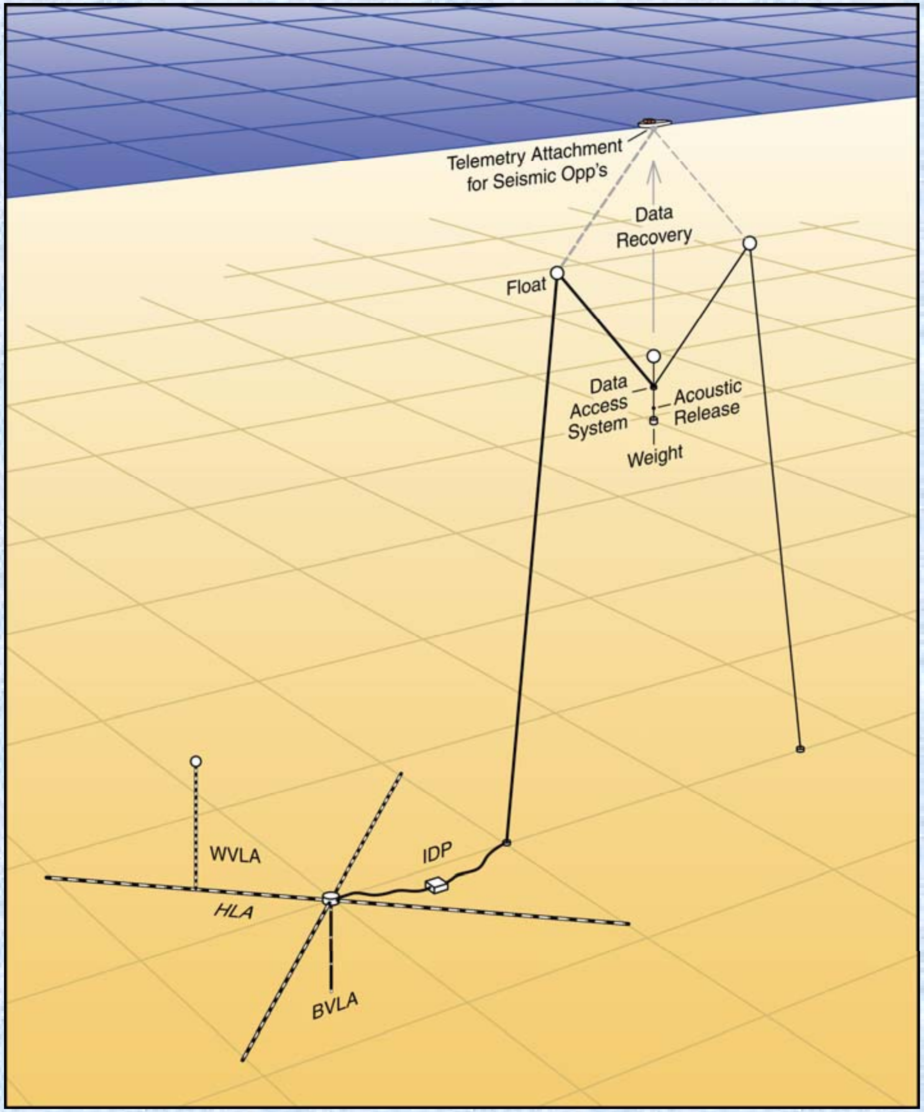
Phase 2: Evaluation of DCR Method for Future 4D Monitoring of Hydrate production

- Tasks 2.1-2.3: Reconfigure system for long-term, seafloor operation.
  - Problem: Integration of DCR system into site infrastructure.
  - Risk: Unforeseen problem in reconfiguring the system.
  - Critical Milestone: Semi-autonomous operation by the end of 6/2008.

- Tasks 2.4-2.6: Long-term monitoring.
  - Problems: Power, data storage, data retrieval.
  - Risks: Equipment failure during long-term deployment.
  - Critical Milestone: Analysis of monitoring data complete by end of 9/2009.

Phase 2: Long-term Fixed Monitoring





Data will be accessed at the sea surface on acoustic command using a custom-made device dubbed the "Big M".

Project Budget

Phase 1 schedule and expenditures.

Phase 1 – Bottom-Towed DCR Survey of MC 118 October 2006 – Mar. 2008	Requested Amount	Baylor U Contribution
Task 1.3 Jan. - June 07, Adaptation of DCR System.		
Components for AGI SuperSting R8 IR	35,000	
56 graphite electrodes and connectors from AGI	8,560	
Construction of bottom-towed array by SDI	25,000	
Pressure Housing and Assembly by SDI	25,000	
Task 1.4 April-June, 07 Test of Seafloor DCR System		
Task 1.5 July-Dec., 07 Bottom-Towed DCR Survey of MC 118		
Task 1.6 Oct. 07– Mar., 08, Analysis of DCR Survey Data		
Salaries	7,141	21,742
Travel	4,810	
Publication charges	2,000	
Fringe benefits	2,000	6,088
Total direct cost Phase 1	111,251	27,830
Overhead	22,389	5,601
Phase 1: totals	**133,640**	**33,431**

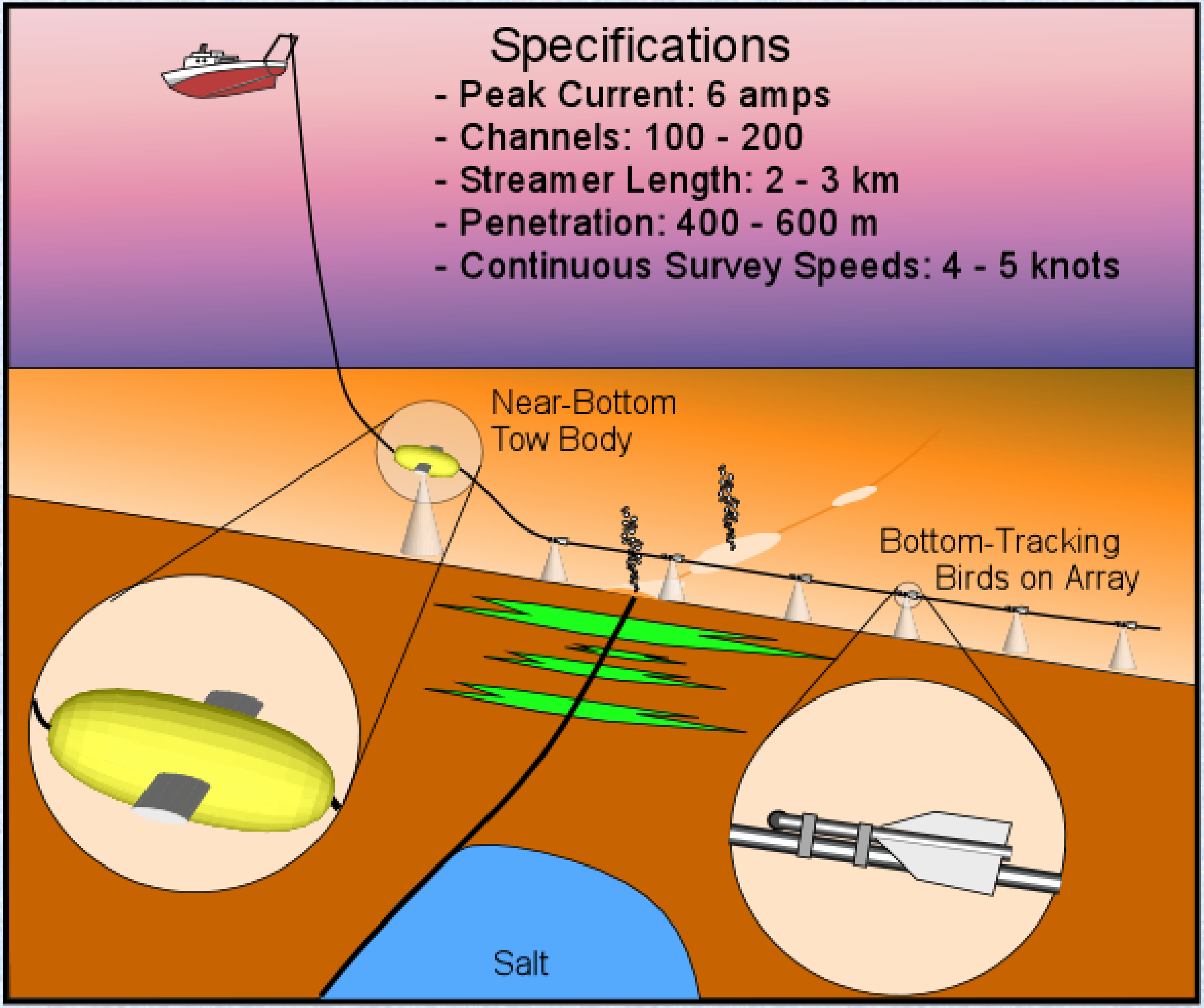
Project Budget

Phase 2 schedule and expenditures.

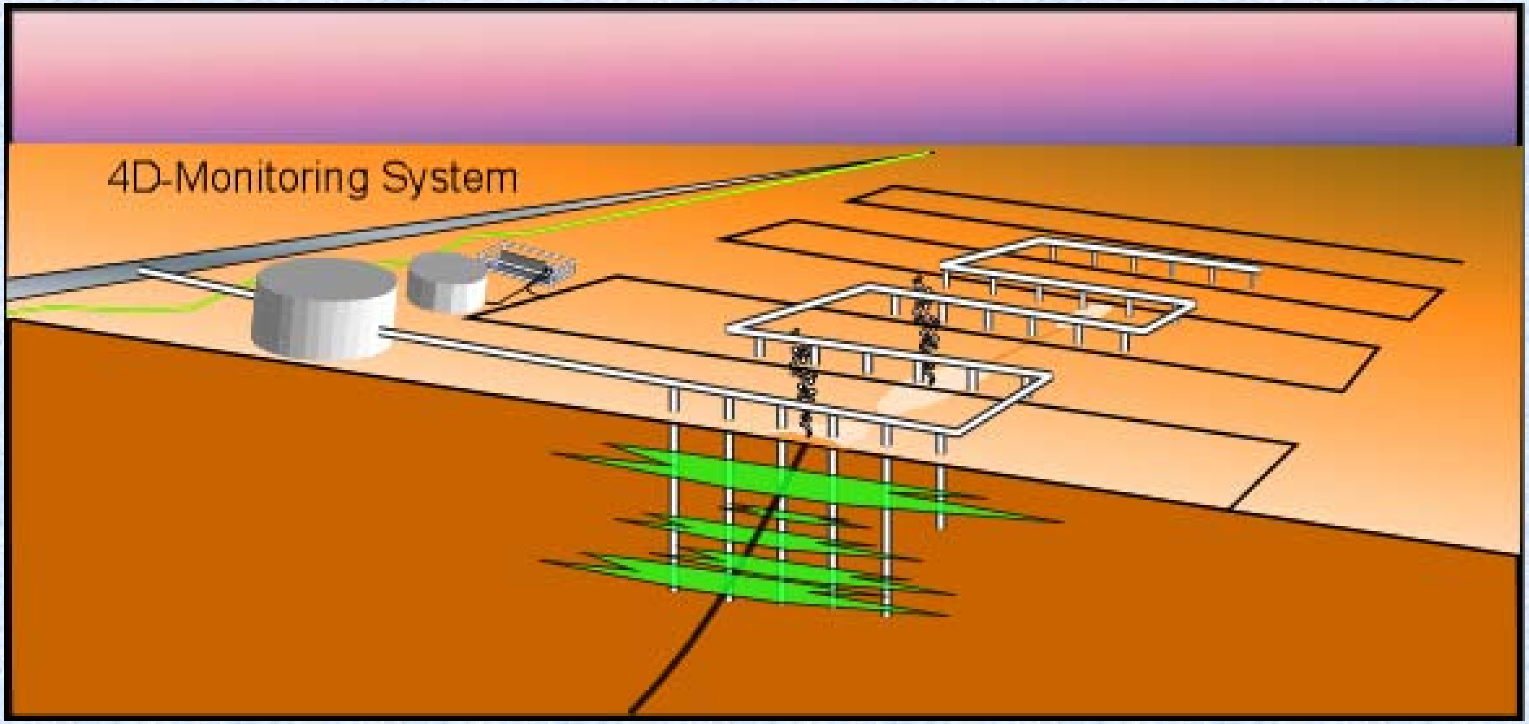
Phase 2 - Continuous DC Resistivity Monitoring January 2008 to August 2009	Requested Amount	Baylor U Contribution
Task 2.1 April-June, 2008, Remote Operation DCR Monitoring System		
Task 2.2 April-June, 2008, Re-configuration of DCR System for Long-Term Monitoring		
Remote control unit for SuperSting System	14,770	
Seabed platform by SDI	9,500	
Cabling to central seabed power and data storage	3,000	
Task 2.4 June-Dec. 2008, Deployment of Long-Term Monitoring DCR System		
Task 2.5 Jan. – Sept. 2009, Participation in Periodic Data-Retrieval Cruises		
Task 2.6 Jan.-Sept.2009, Analysis of DCR Long-Term Monitoring Data		
Task 2.7 July-Sept. 2009, Final Report		
Salaries.	69,260	23,058
Travel.	14,210	
Publication charges	2,000	
Fringe benefits	7,572	6,456
Total direct cost for Phase 2	120,312	
Overhead	24,214	5,940
Phase 2: totals	**144,526**	**35,454**

Project totals	**278,166**	**68,885**

Commercial-Scale Exploration DCR System



Commercial-Scale 4D, DCR Monitoring System



Specifications

- Static 3D array
- 100s of channels
- 1000s of electrodes
- Image on daily basis