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

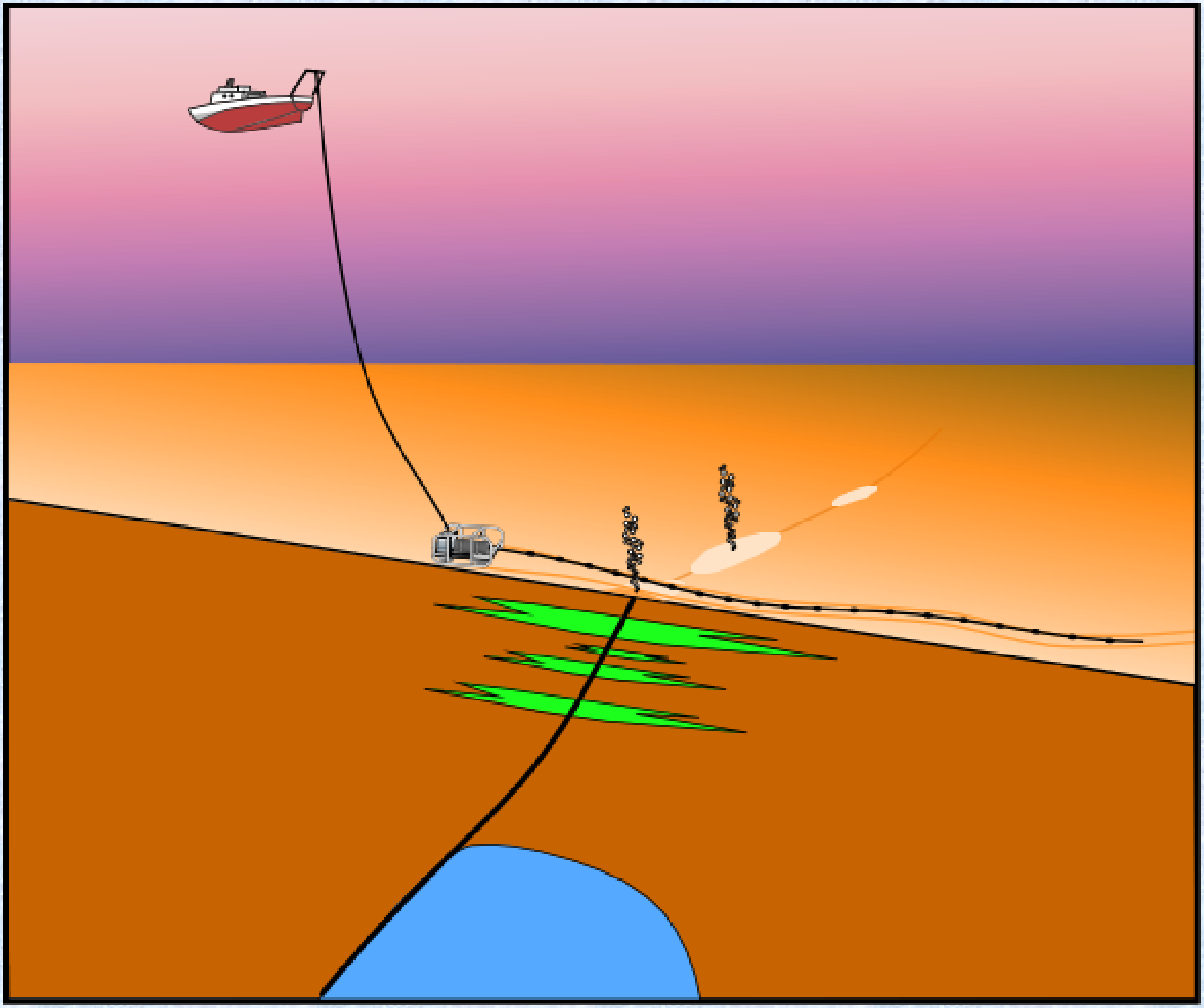
Prime Recipient
John A. Dunbar
Baylor University
Department of Geology
Waco, Texas

DOE Award Number
DE-FC26-06NT42959

NETL Project Manager
Frances Toro

September 18, 2007

Bottom-Towed Direct Resistivity Profiling for Hydrate Exploration



Project Status

Phase 1: Evaluate DCR Method for Reconnaissance Surveys

Task 1: Build Ocean-Bottom Resistivity System

- Budget: \$88 k of \$138 k Federal funds spent/committed
- Schedule: One quarter behind
- Complete and test system Fall 2007

Task 2: DCR Survey of MC 118

- Conduct survey during winter 2008
- Process and interpret data during spring 2008

Project Organization

Baylor University, Waco, Texas (John Dunbar)

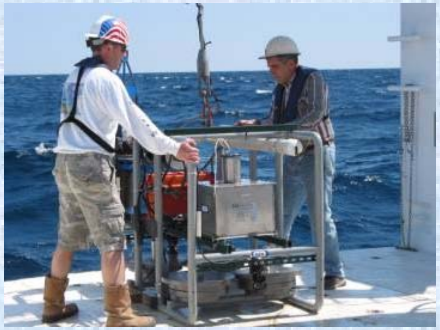
Shear wave seismology, marine seismic acquisition, sub-bottom profiling and electrical methods.

Geophysical data acquisition, processing, and interpretation.

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

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

Electronic components for DCR system.



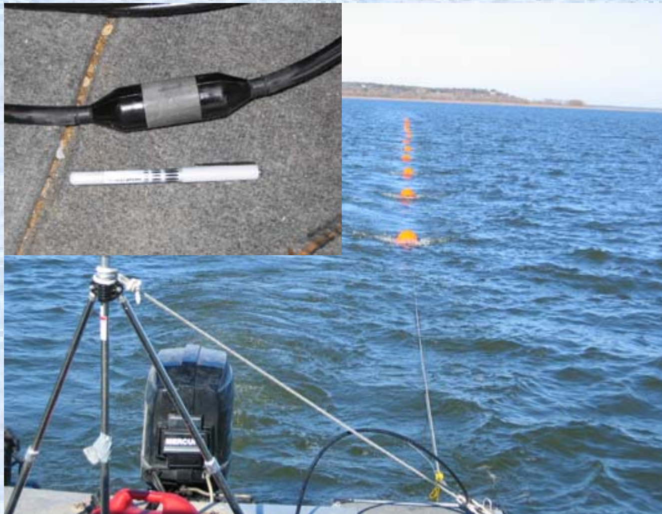
Specialty Devices, Inc., Wylie, Texas (Paul Higley)

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

Assembly of ocean-bottom DCR system, field deployment.

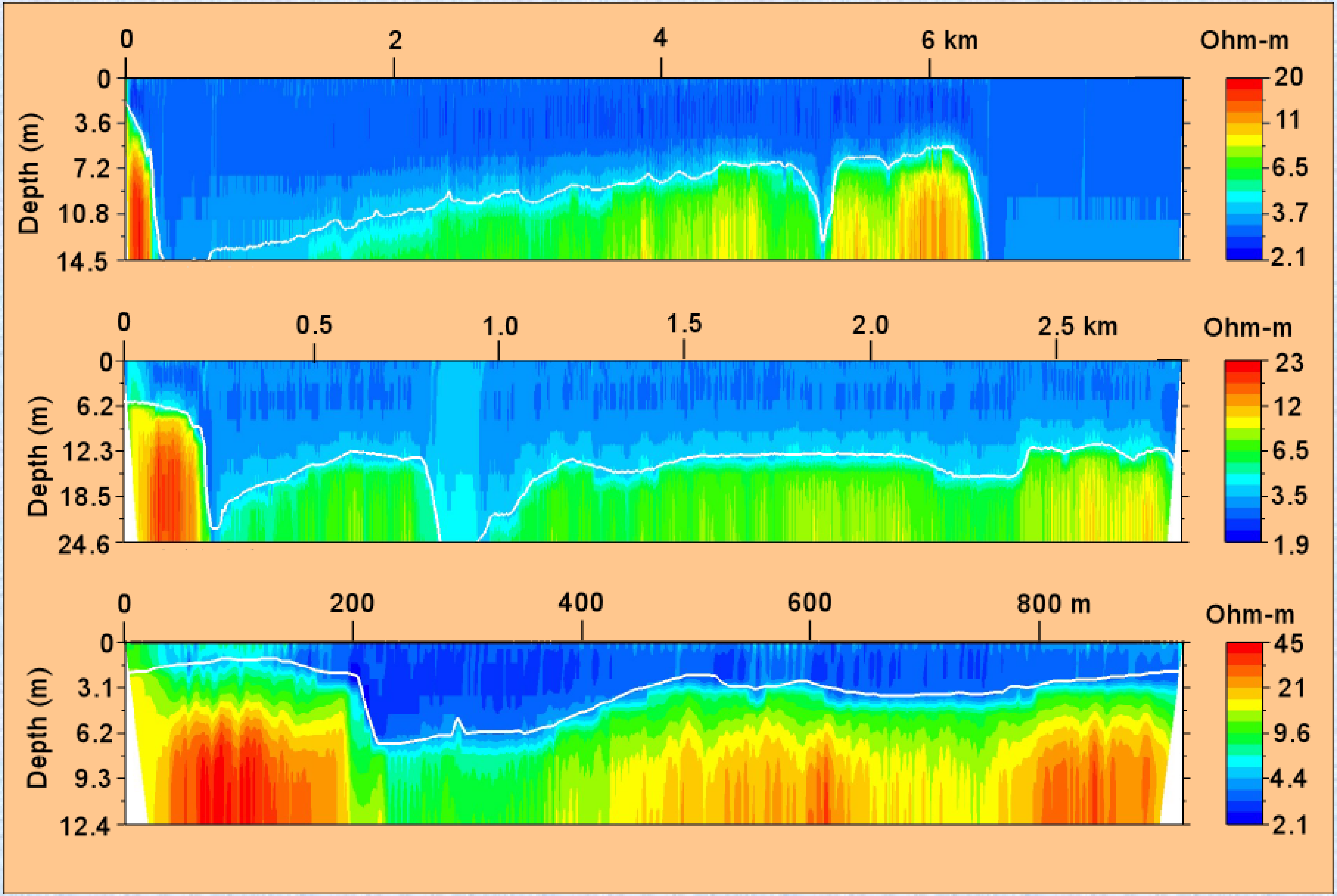
John Dunbar
Professional Background

- BS & MS Virginia Tech, 1973-79: Gravity and Heat Flow
- Arco Research, Plano, 1979-84: Shear Wave & Marine Seismology
- PhD UT Austin, 1984-88: Basin Subsidence, Lithospheric Dynamics, Marine Geophysics
- Shell Research, Bellaire, 1988-94: Basin & Structural Modeling
- Baylor University, Waco, 1994 - : Sub- bottom Acoustic and Resistivity Profiling



Shallow Marine DCR System

Example Inverted DCR Sections from Lake Whitney, Texas

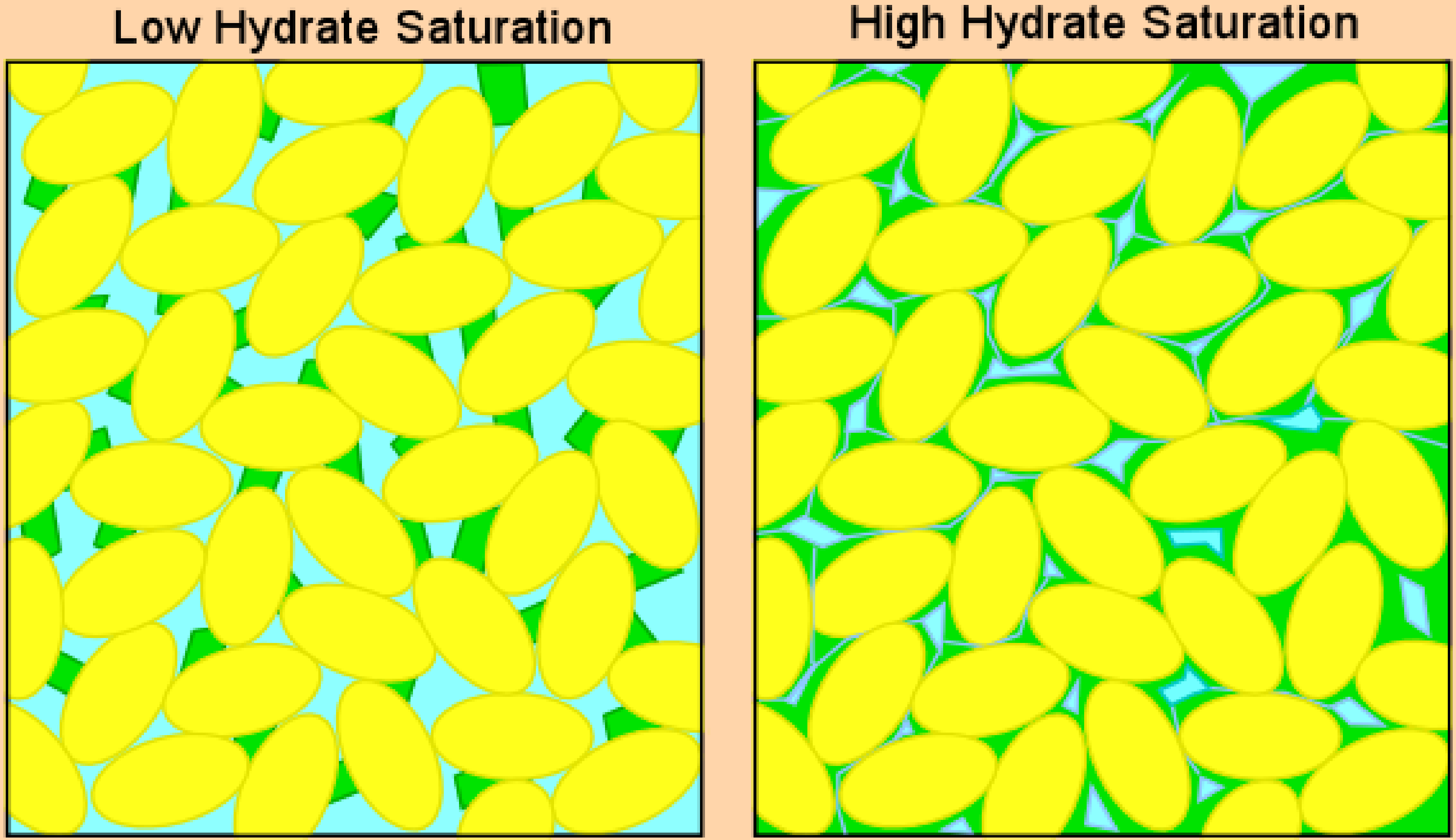


Alternate Paths to the "Holy Grail" of Marine Gas Hydrate Exploration

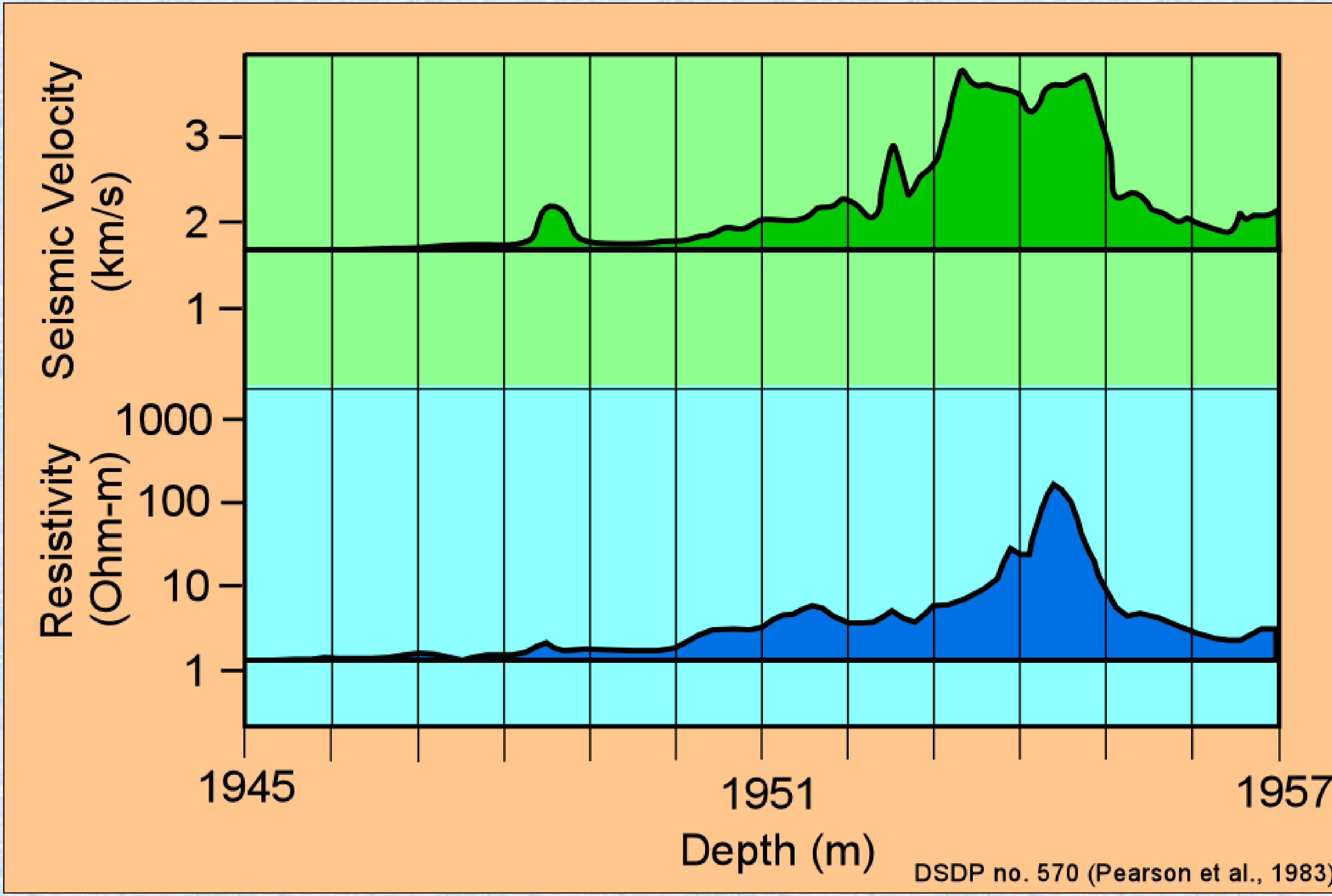
- **Goal**
  - Geophysical method for reliably mapping the concentration of hydrates within the stability zone
- **Seismic methods**
  - Full waveform seismic inversion
  - AVO
  - Deep-towed and ocean-bottom reflection systems
  - Refraction tomography
- **Electrical methods**
  - Controlled source EM
  - Direct current resistivity?

Johnson and Max, The Leading Edge, May 2006

Mechanical Versus Electrical Response to Hydrate Saturation



What Electrical Methods Bring to the Table



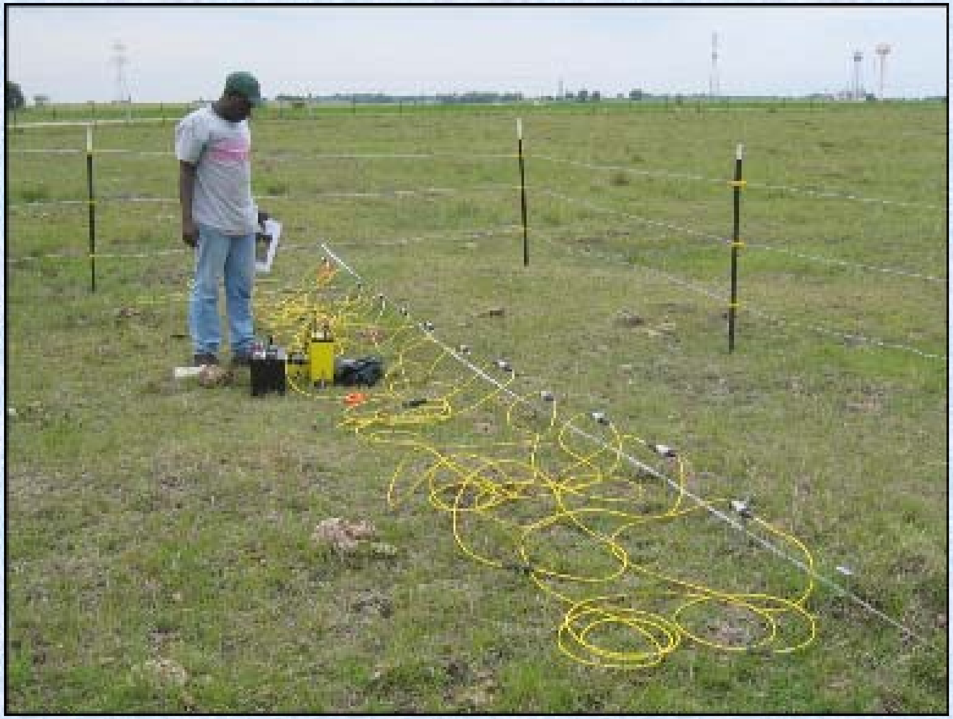
Controlled Source EM Verses Direct Current Resistivity

Characteristic	CSEM	DCR
Coupling Through Air	✓	
Coupling Through Casing	✓	
Coupling in Marine Environment	✓	✓
Offsets to 10s of km	✓	
Offsets to a few km	✓	✓
Interchangeable Sources/Receivers		✓
Expandable to 100s to 1000s of sensors		✓

Near Surface EM and DCR Instruments

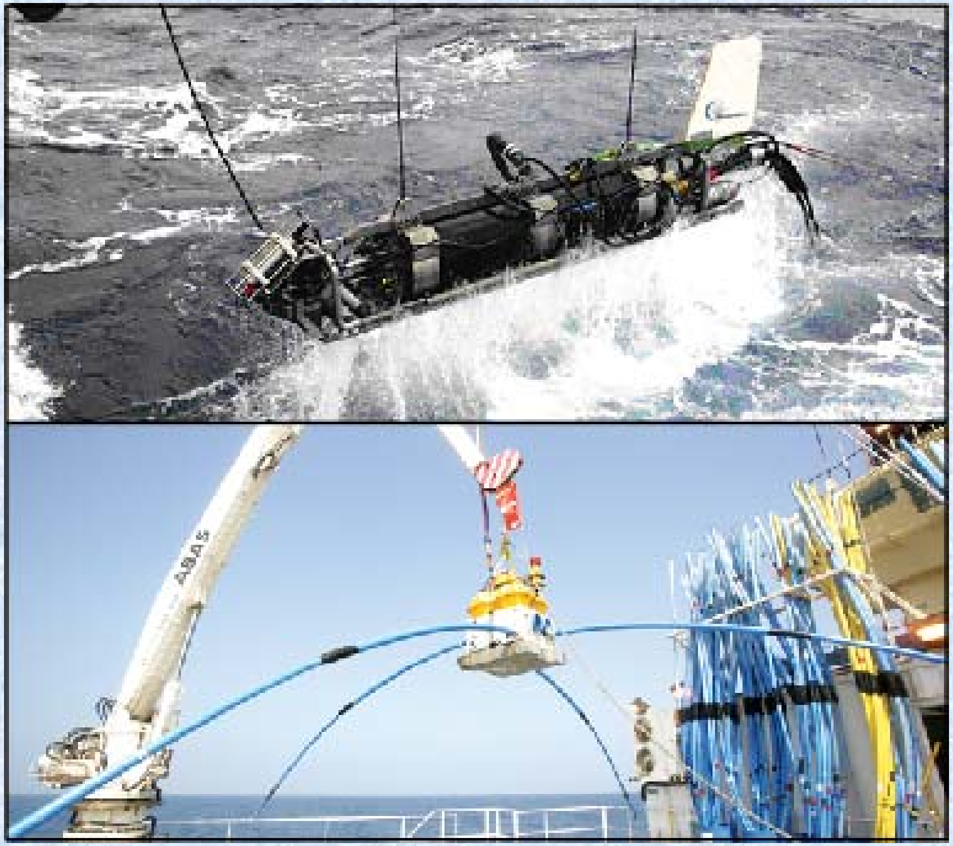
Geonics EM31

AGI Super Sting



Controlled Source EM Vs DC Resistivity

CSEM Source & Receiver



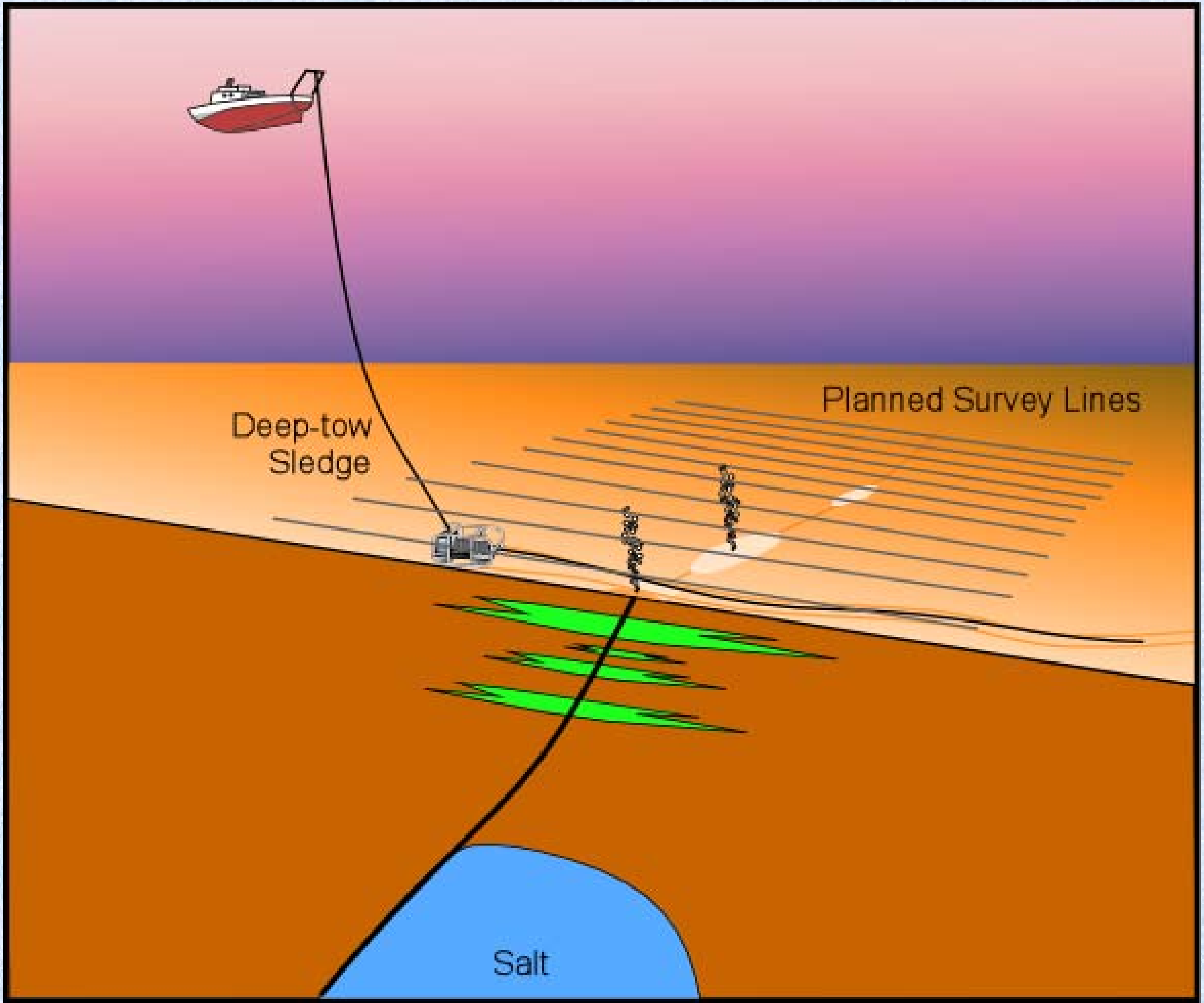
DCR Source & Receiver

www.WesternGeco.com

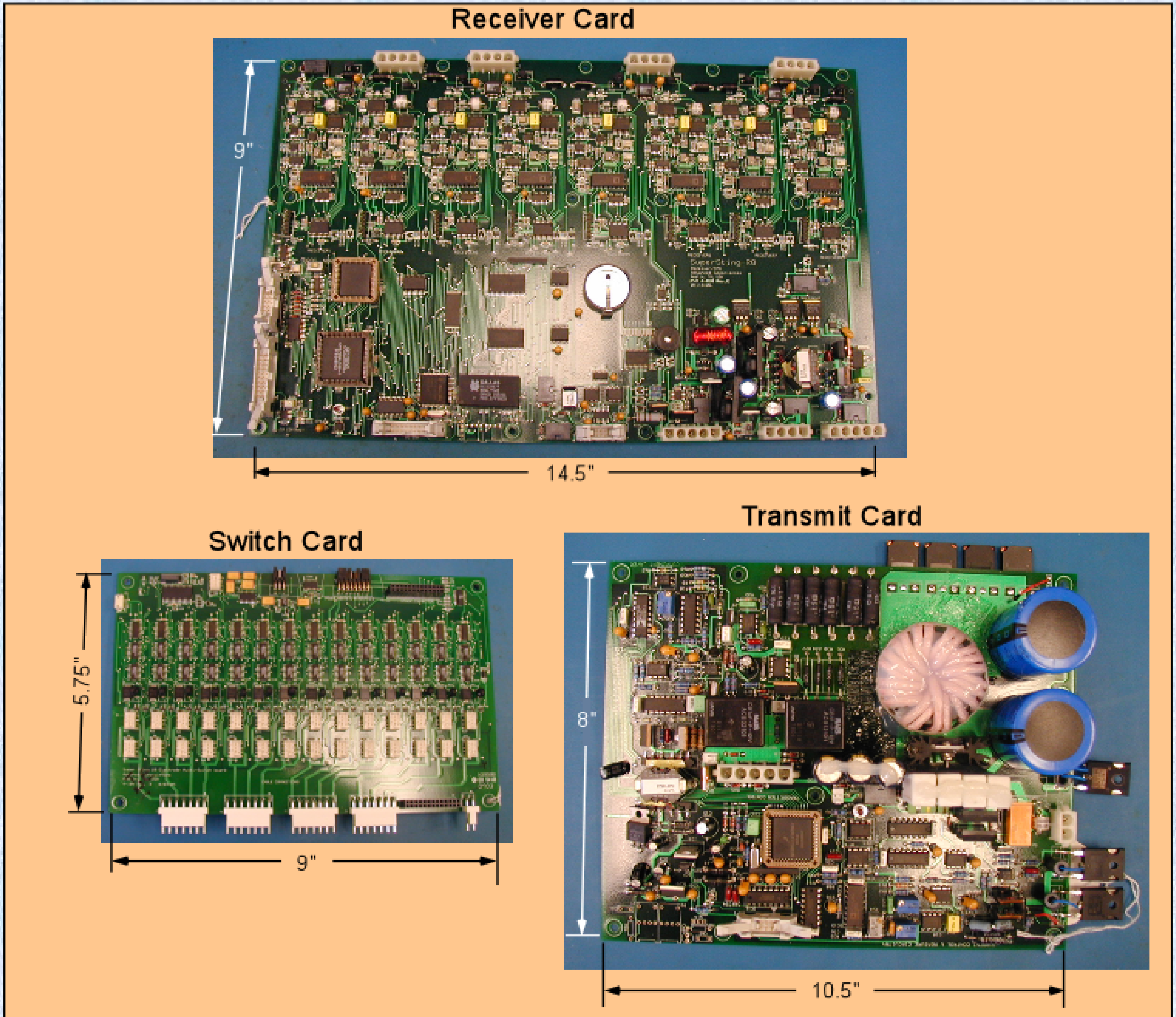
Requirements for Commercial Hydrate Exploration System

- Map hydrate concentration
- Penetration to 1 km
- Continuous acquisition at 4 to 5 knots
- 3D coverage for exploration
- 4D coverage for production
- True 3D tomographic imaging

Phase 1: Ocean-Bottom DCR Reconnaissance Survey

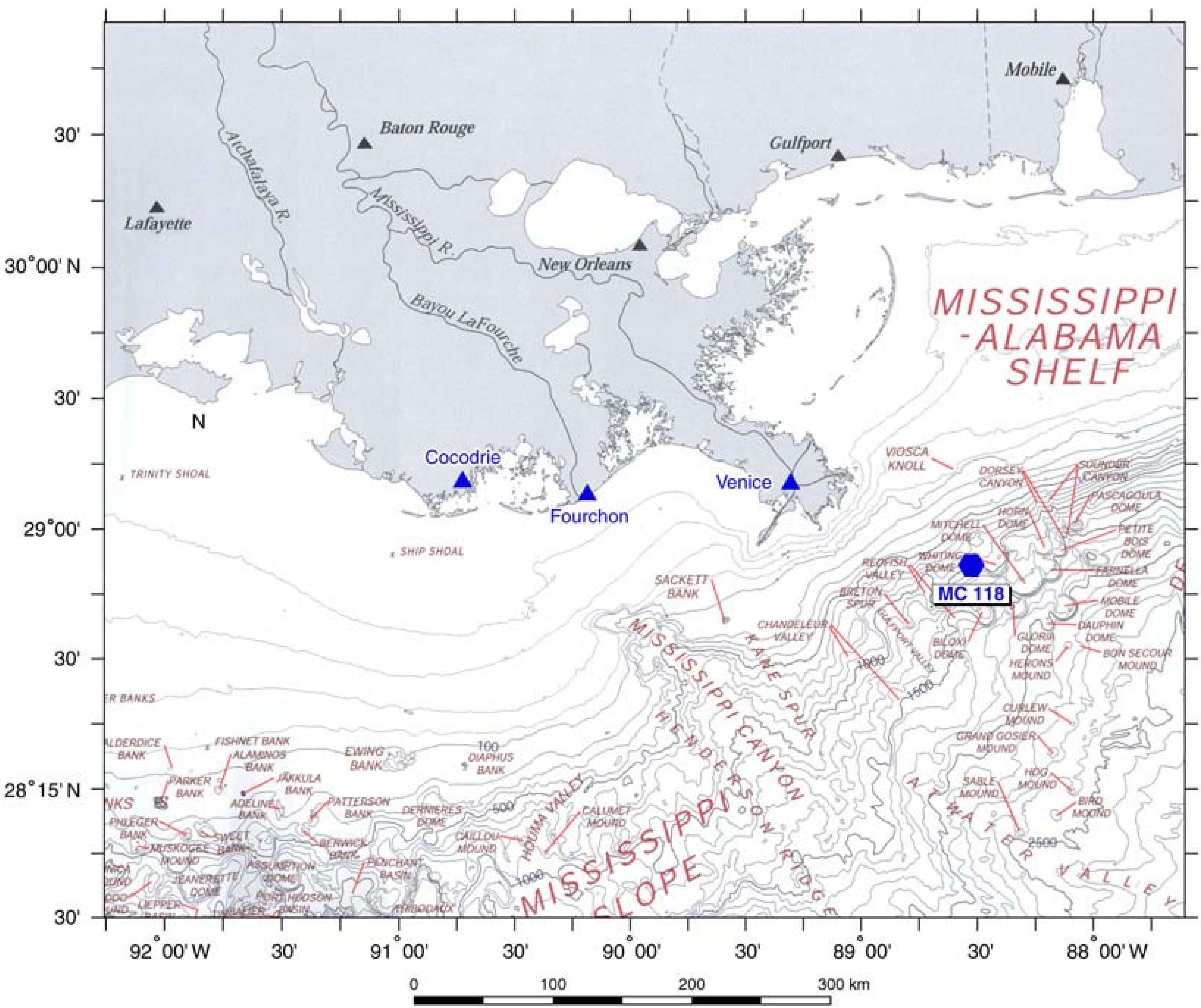


DCR System Components



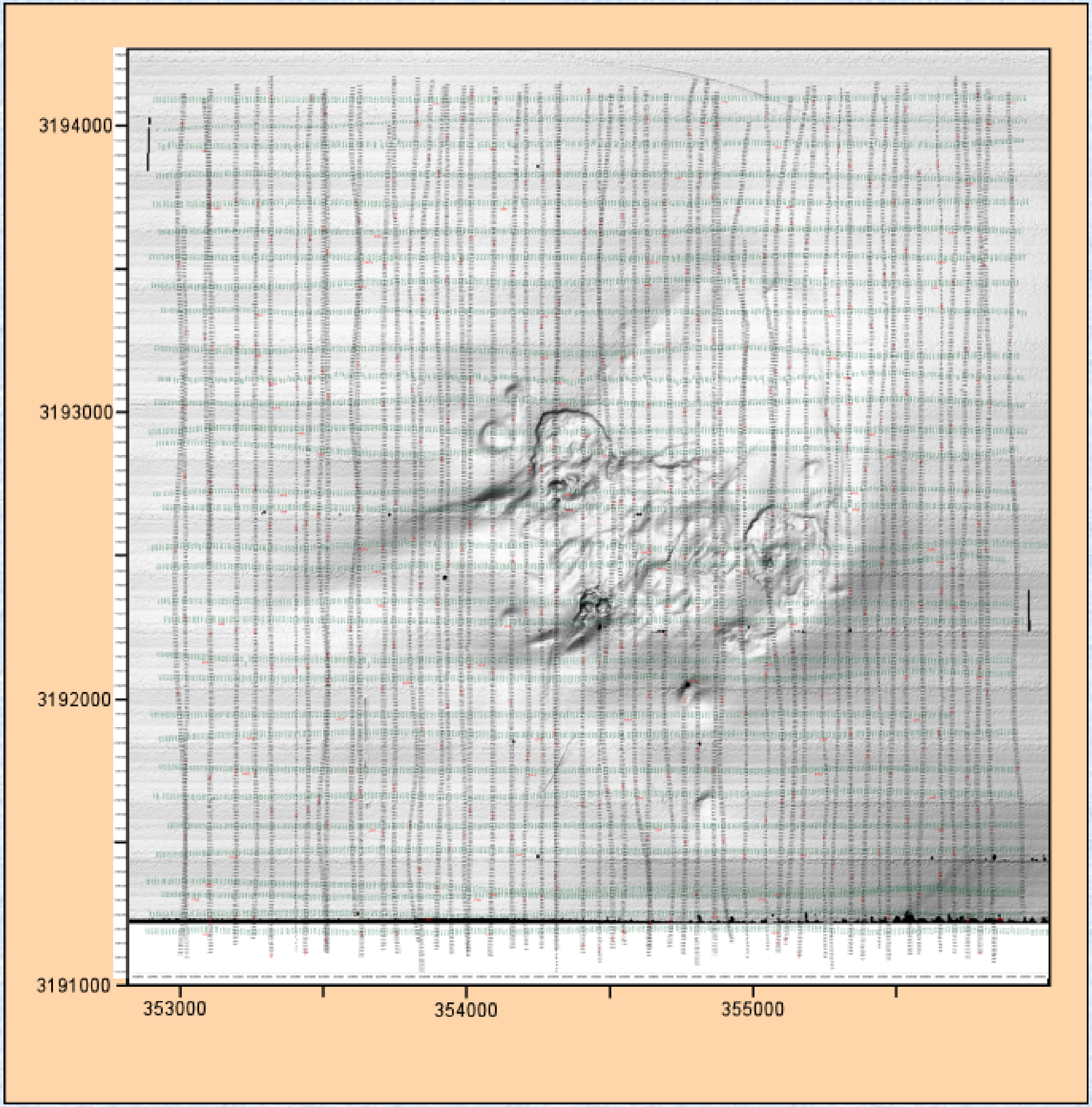
Instrument Pressure Housing Design

Bellamare, Inc., La Jolla, California



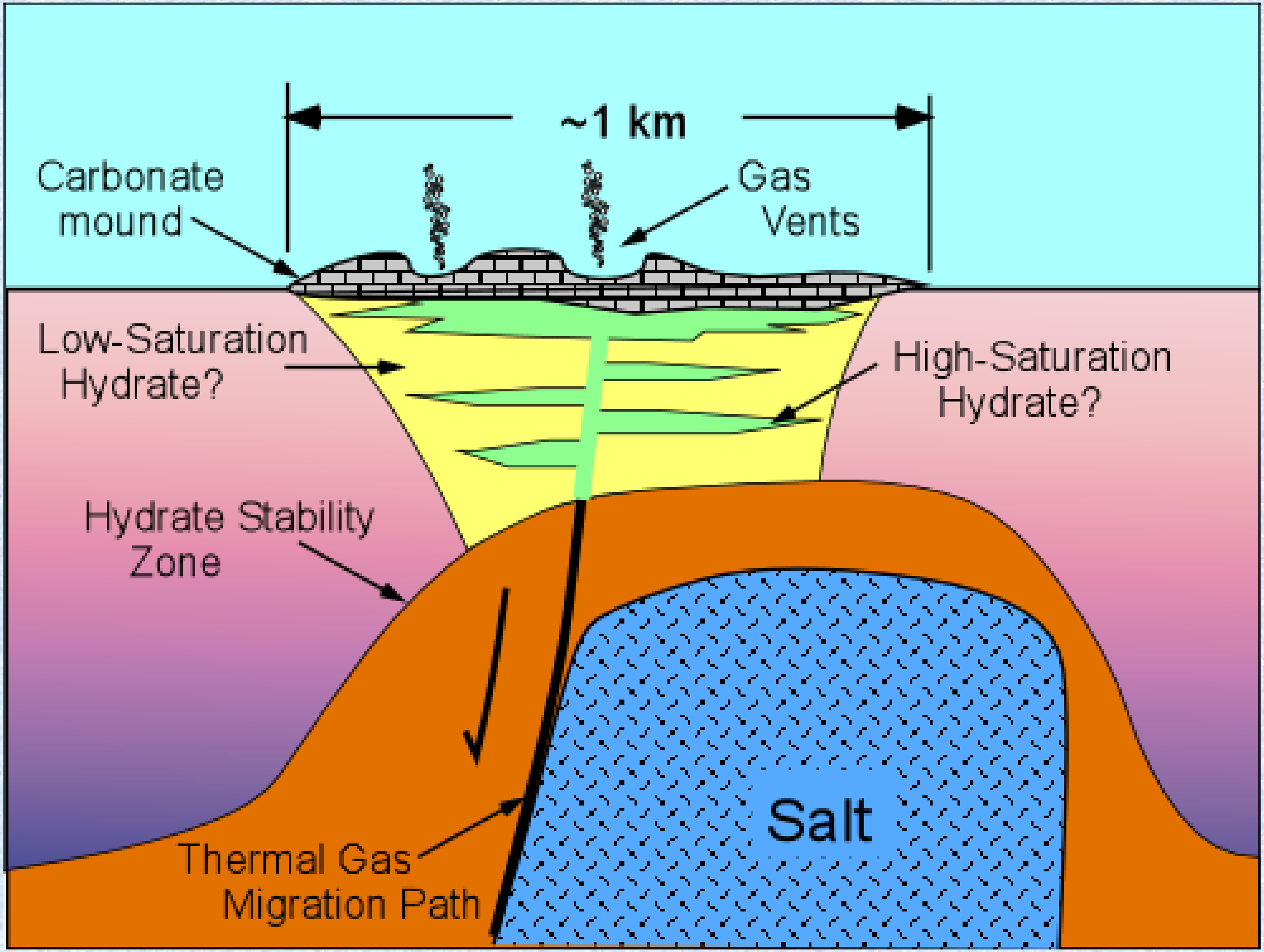
Mobile
Baton Rouge
Gulfport
Lafayette
Atchafalaya R.
Mississippi R.
New Orleans
Bayou LaFourche
MISSISSIPPI
-ALABAMA
SHELF
N
Cocodrie
Fourchon
Venice
TRINITY SHOAL
SHIP SHOAL
VIOSCA KNOLL
DORSEY CANYON
SOUNDER CANYON
PASCAGOULA DOME
HORN DOME
MITCHELL DOME
PETITE BOIS DOME
WHITING DOME
REDFISH VALLEY
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
HENDERSON RIDGE
CURLEW MOUND
GRAND GOSIER MOUND
HOG MOUND
SABLE MOUND
BIRD MOUND
ATWATER VALLEY
MISSISSIPPI SLOPE
ALDERDICE BANK
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
MUSKOGEE MOUND
BERWICK BANK
ASSUMPTION DOME
PENCHANT BASIN
JEANERETTE DOME
PORT HUDSON BASIN
THIBODAUX
100
500
1000
1500
2500
30'
30°00' N
29°00'
28°15' N
92°00' W
91°00'
90°00'
89°00'
88°00' W
0
100
200
300 km

Deep-Tow Seismic Grid, Vent Area MC 118

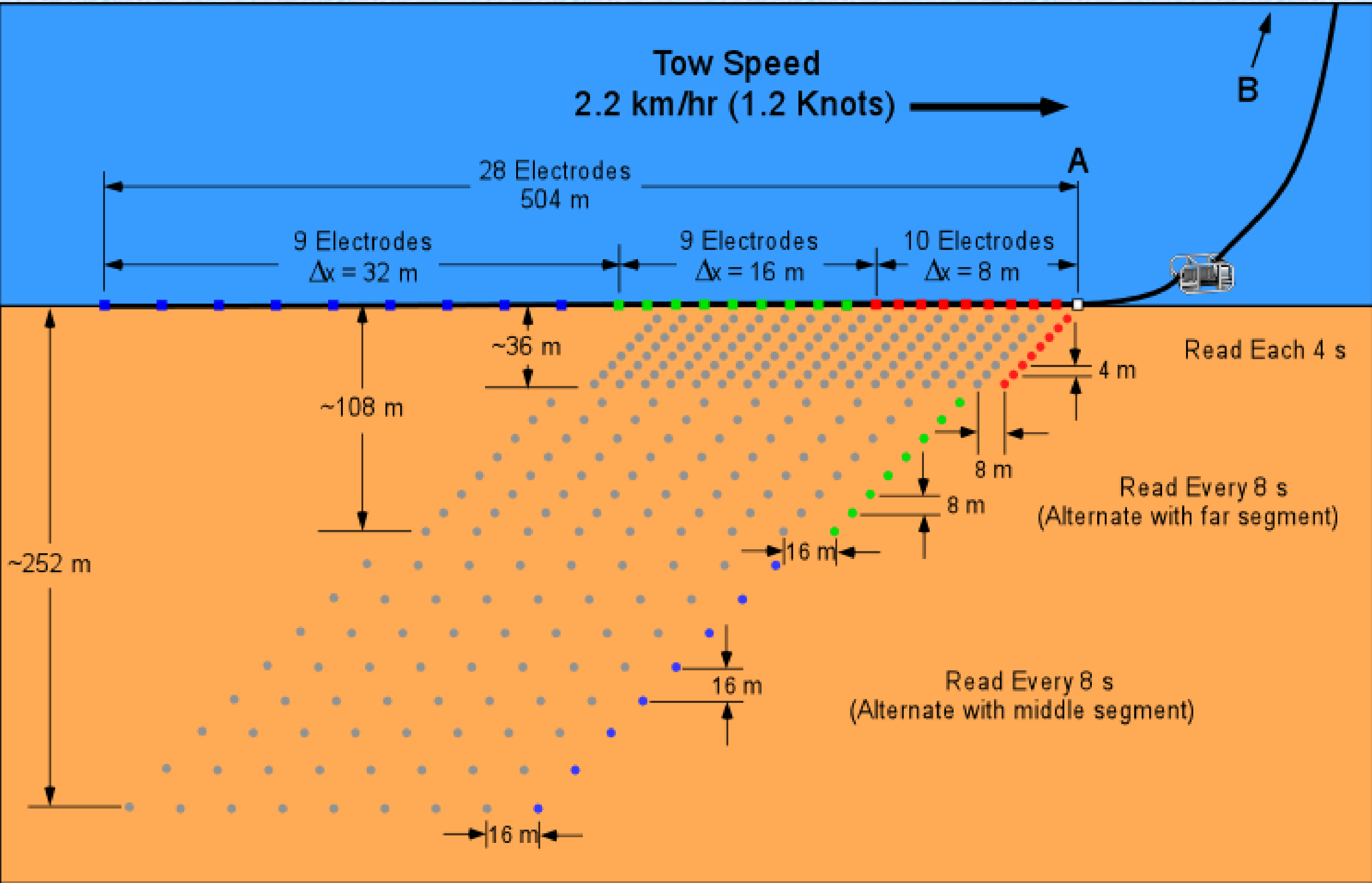


Massive Gas Hydrate Outcrop at MC 118

Conceptual Model of MC 118 Methane – Hydrate System

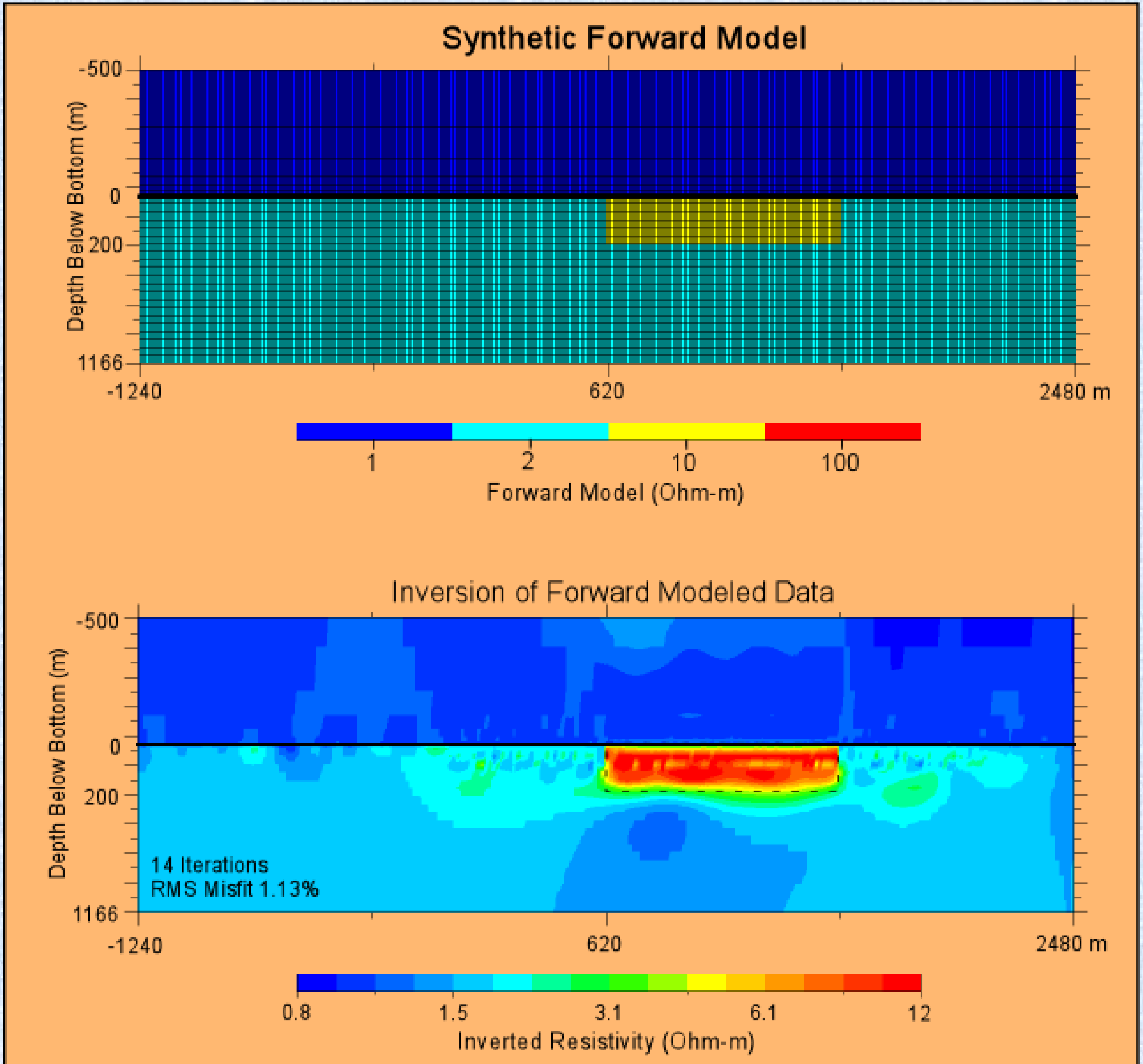


Deep-Tow, ~Pole-Dipole, CRP Geometry

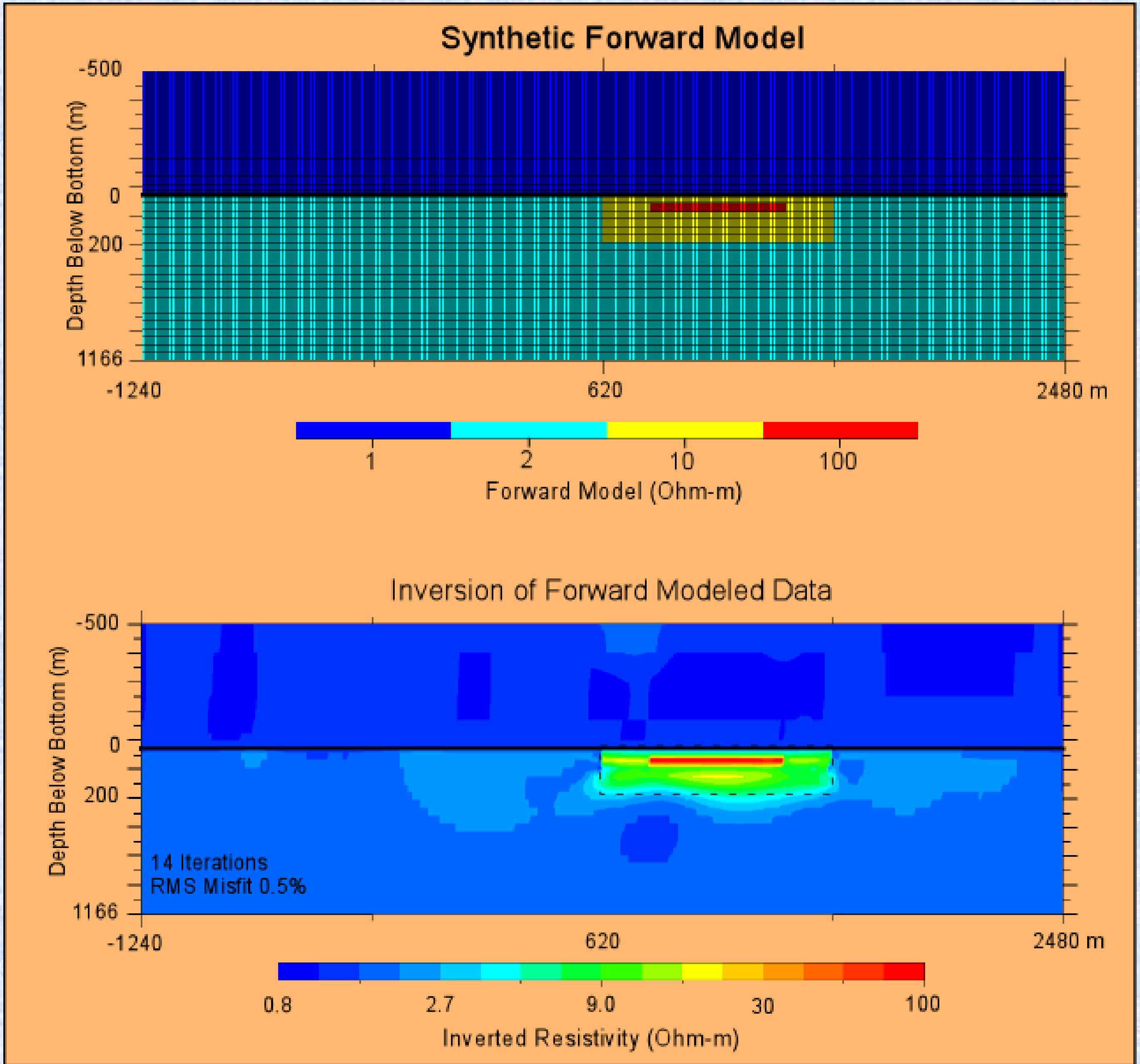


AGI's Remote Control Interface Via RS232 Emulation

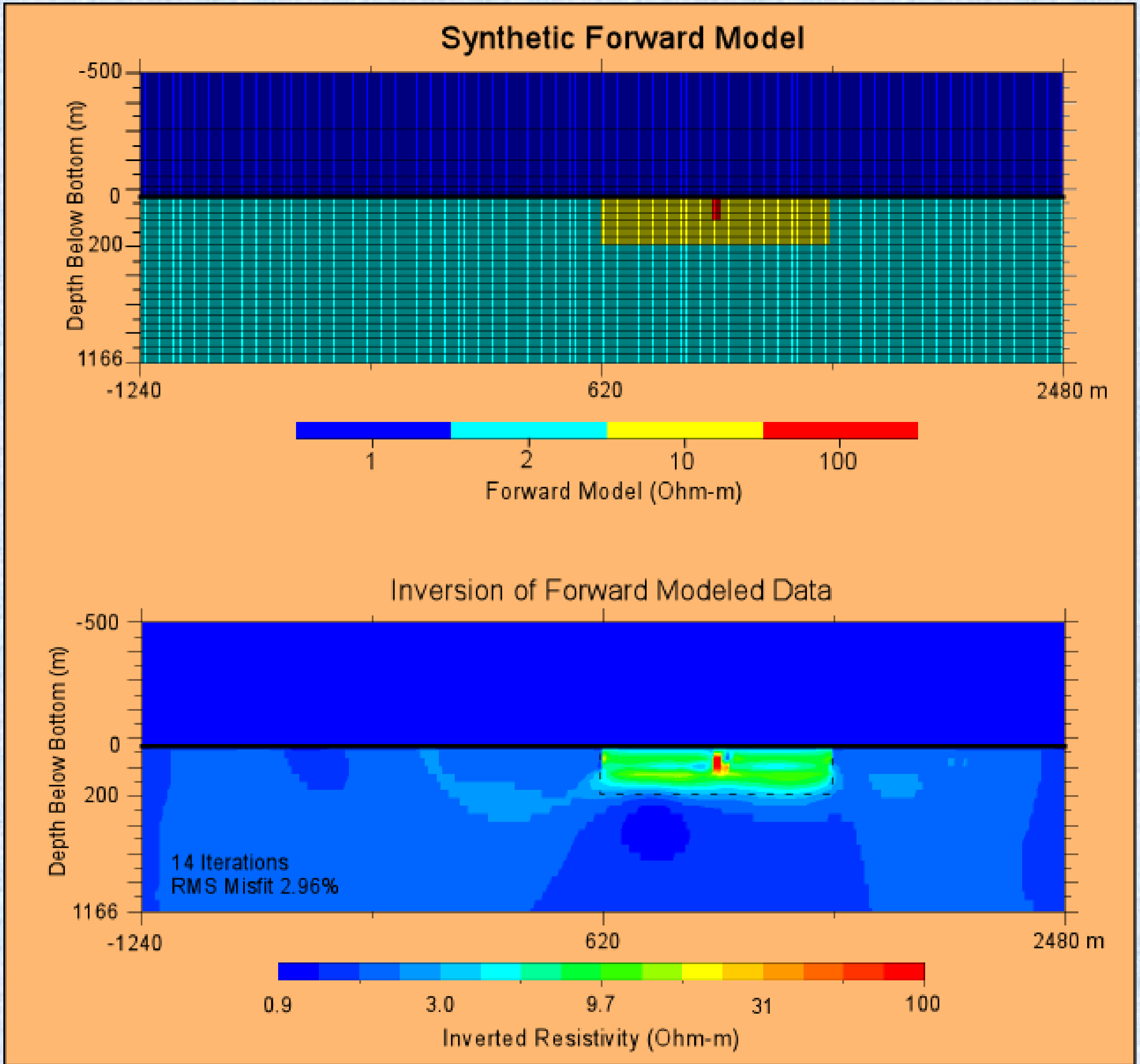
Synthetic Model Test: 200 m Thick, Low Saturation Layer



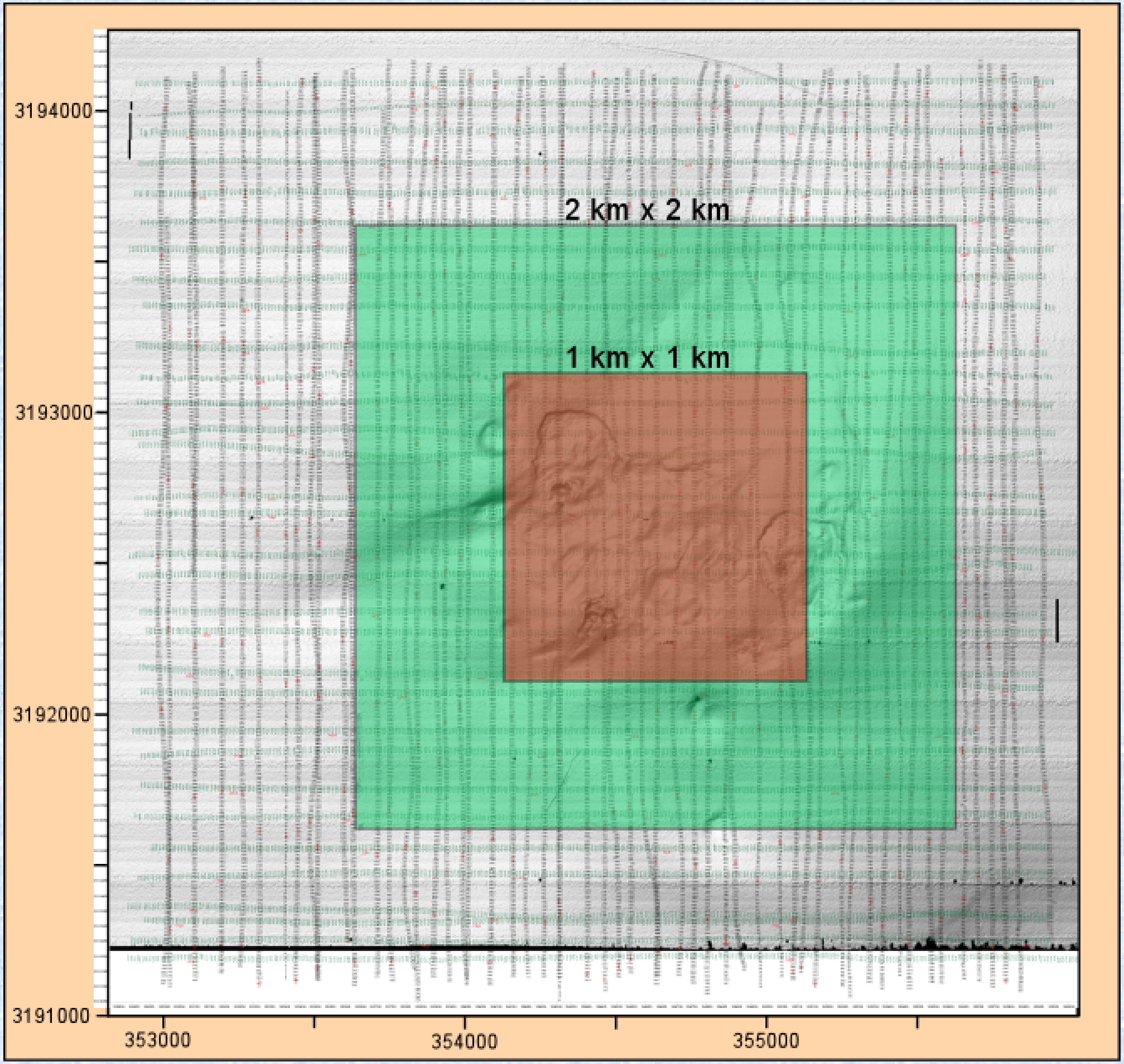
Synthetic Model Test: Low Saturation Layer Plus High Saturation Sill



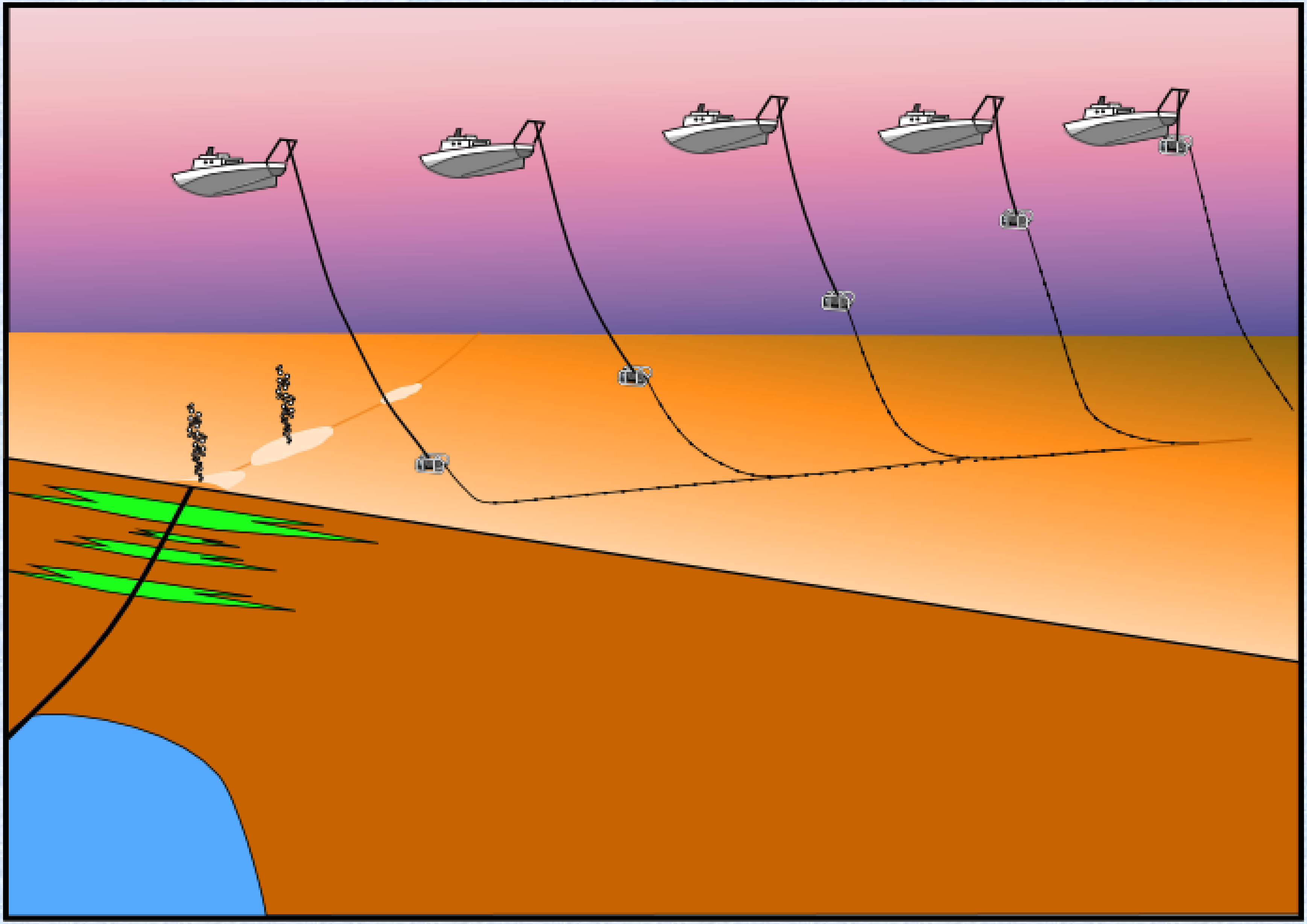
Synthetic Model Test: Low Saturation Layer Plus High Saturation Plug



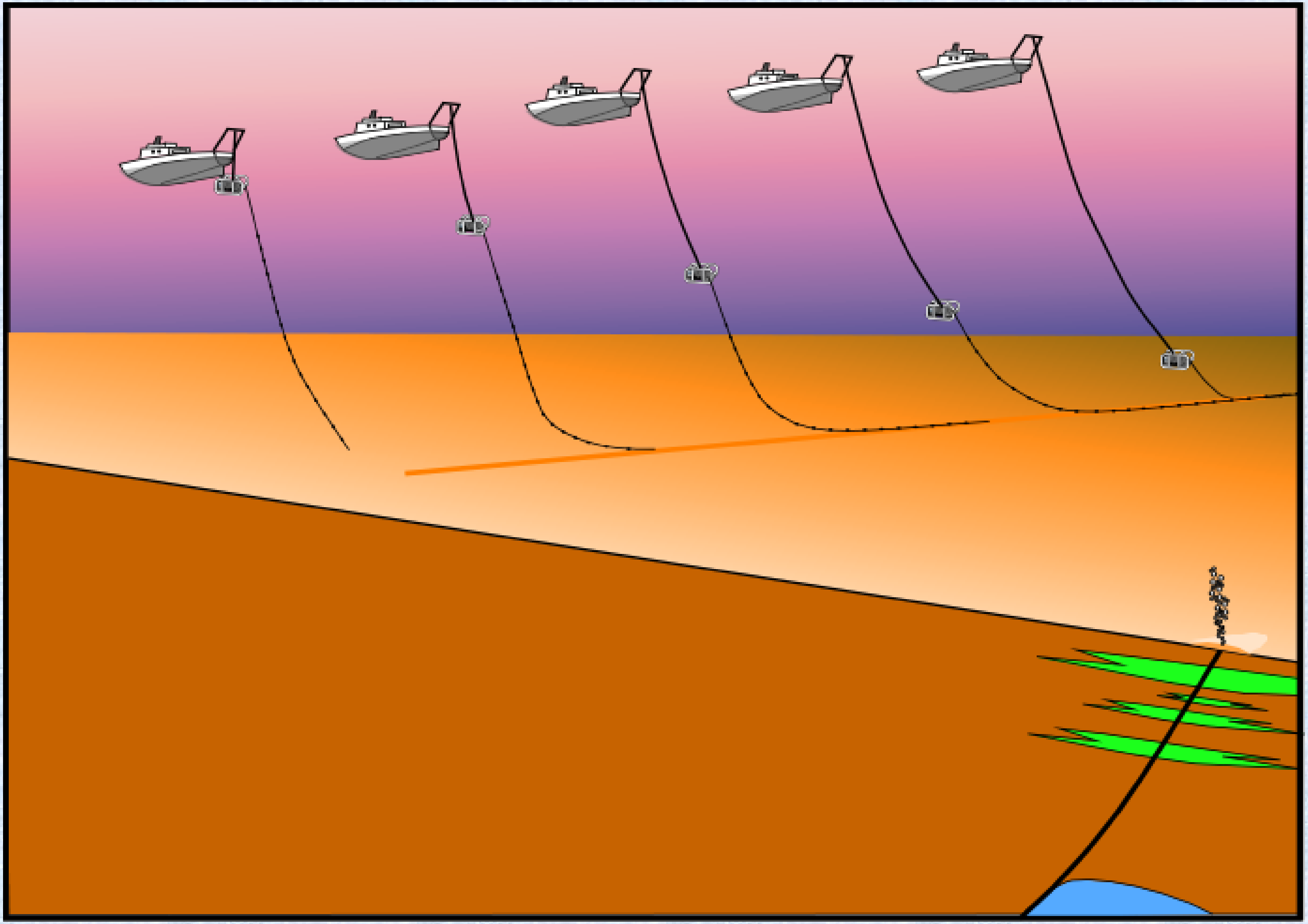
Proposed and Preferred DRC Survey Footprints



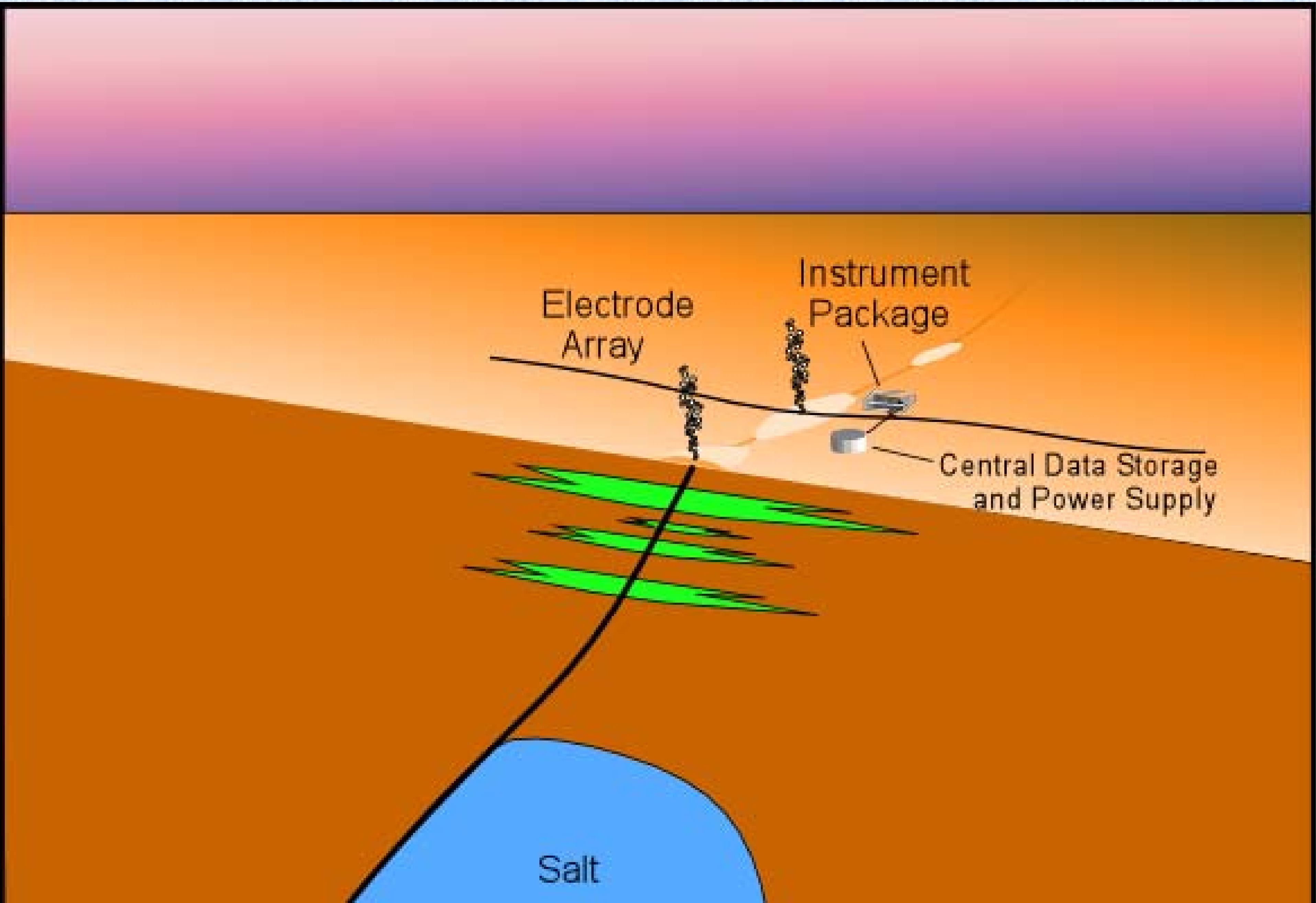
Instrument Deployment and Line Change



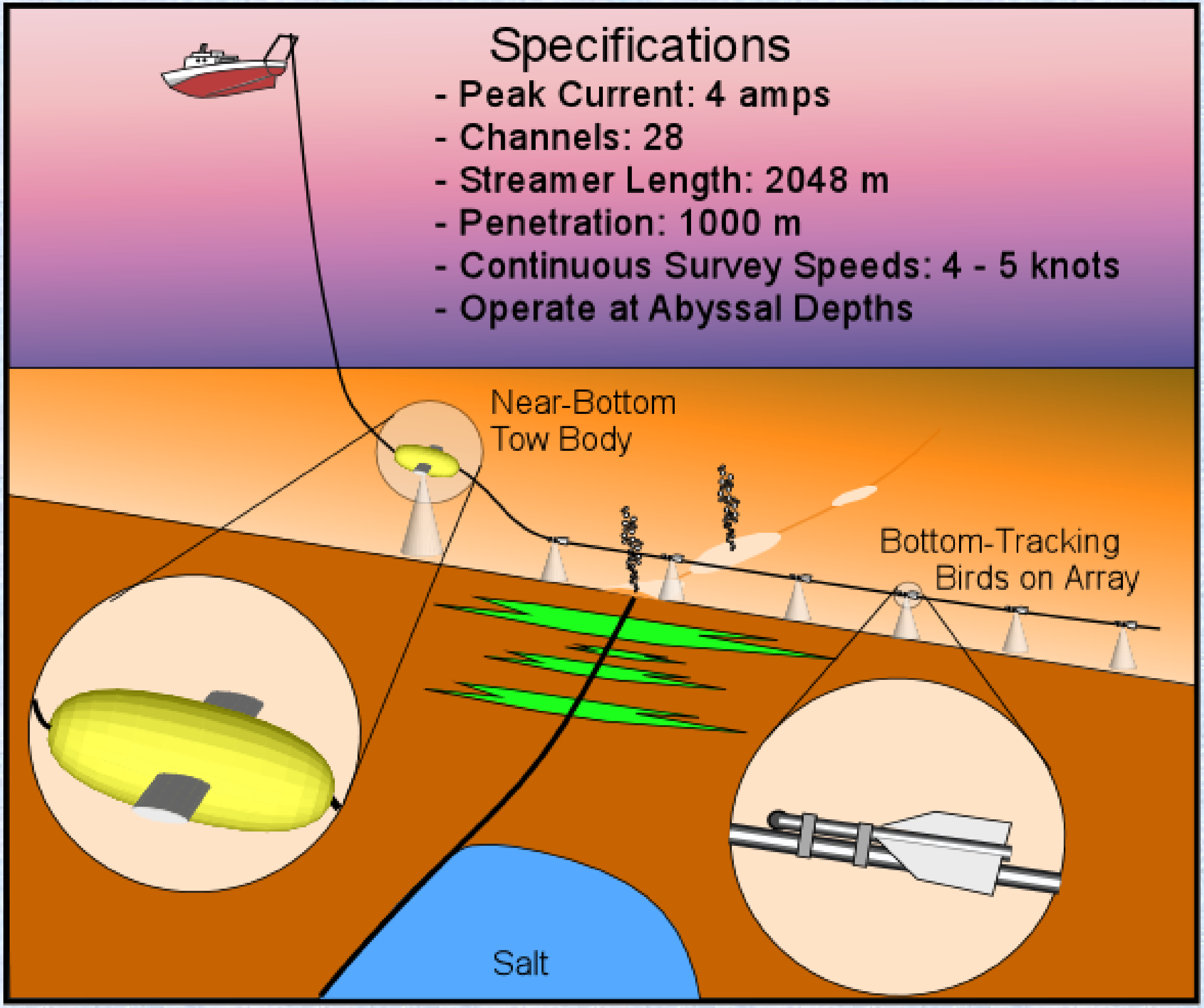
Instrument Retrieval and Line Change



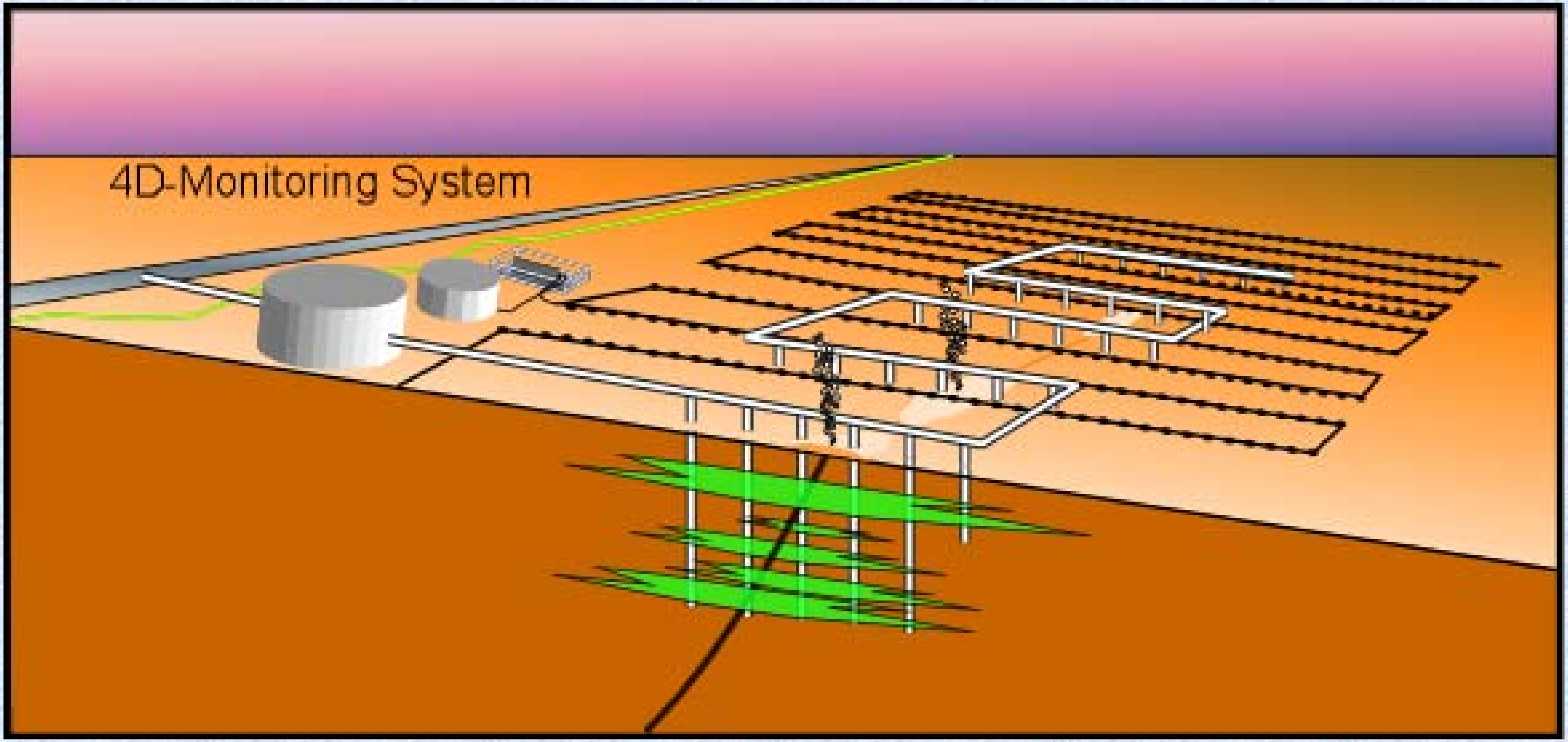
Phase 2: Long-term Fixed Monitoring



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