Fourth Annual Conference on Carbon Capture & Sequestration

Developing Potential Paths Forward Based on the Knowledge, Science and Experience to Date

Geologic –Frio Brine Field Project (2)

Time-Lapse EM and Seismic Imaging of a CO2 Plume

Kevin Dodds CO2CRC, Australia

May 2-5, 2005, Hilton Alexandria Mark Center, Alexandria Virginia

Motivation

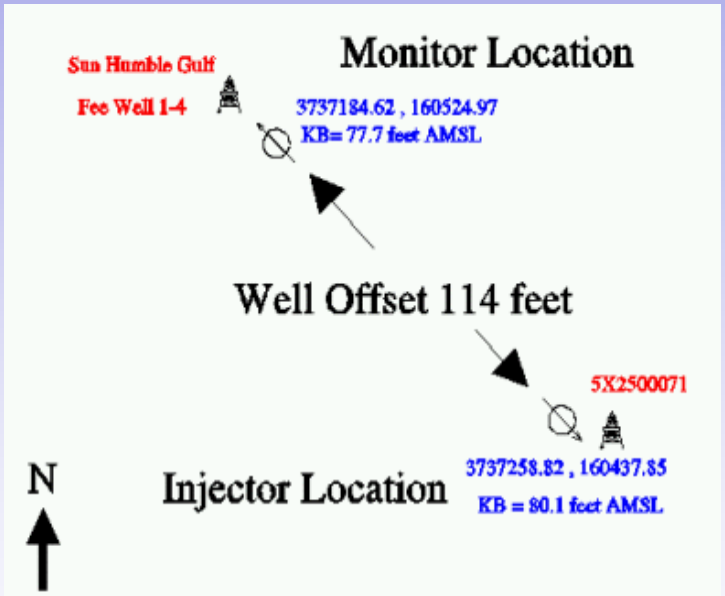
Why is CO2CRC involved in Frio Brine ?

- Frio Brine was nominated as one of 10 International projects that would provide insight into Carbon sequestration
- CO2CRC Contributed acquisition of crosswell EM
- Presence of a researcher on-site for 5 weeks.
- Developing collaborative relationship with LBNL
- Value the input of Susan Hovorka in planning our project, and the interaction with BEG.

Frio Crosswell EM Survey Objectives

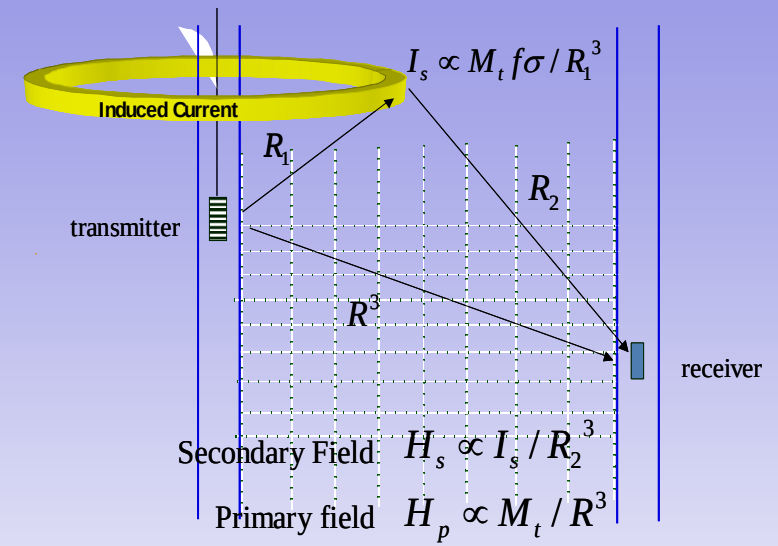
- **The objective of the survey is to evaluate the CO2 injection progress after two weeks of injection in the C sand in the Frio formation in Texas using crosswell EM technique.**

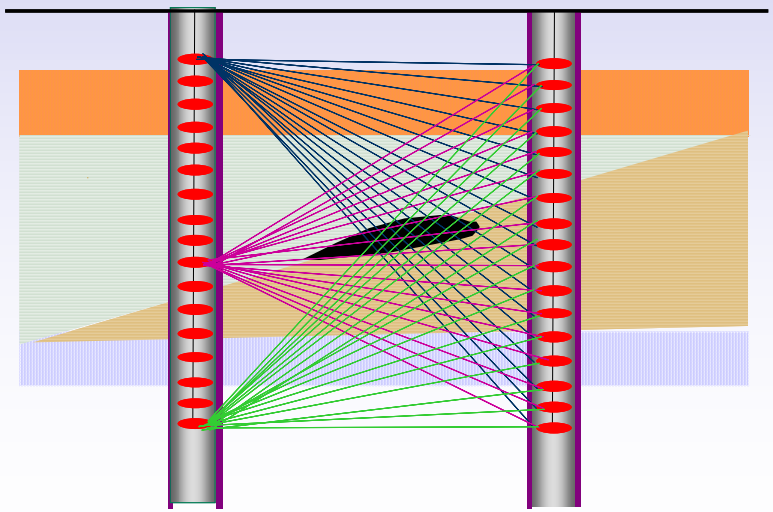
- **Injector well: 5x2500071 (Cased)**
- **Monitoring well: SHG 1-4 (Cased)**
- **Well separation: 114ft**



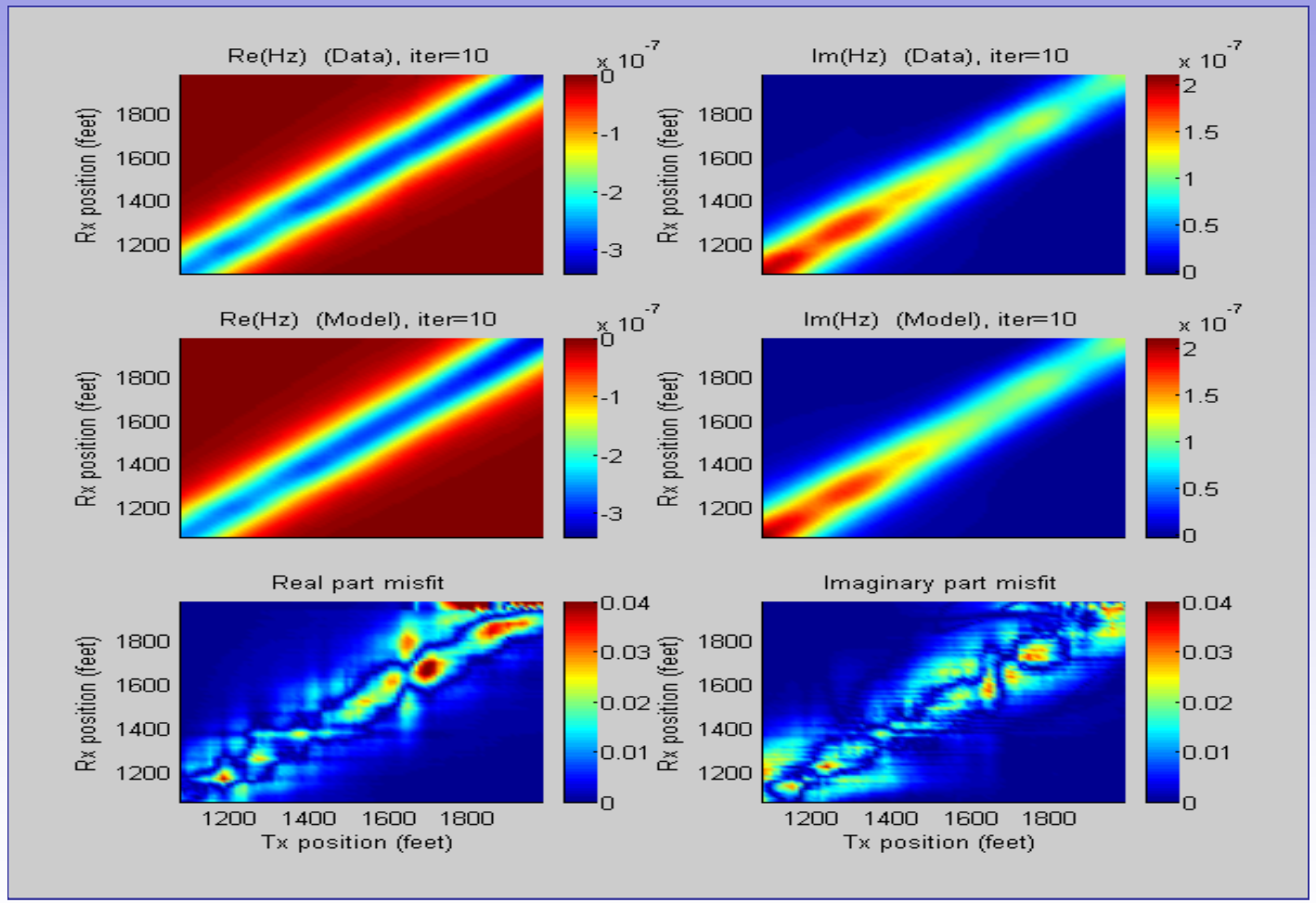
The Technology

- The Crosswell EM system
- transmitter tool and a receiver tool connected with surface wire telemetry and
- deployed with standard wireline equipment.





The Technology



Model

Field Result

Misfit

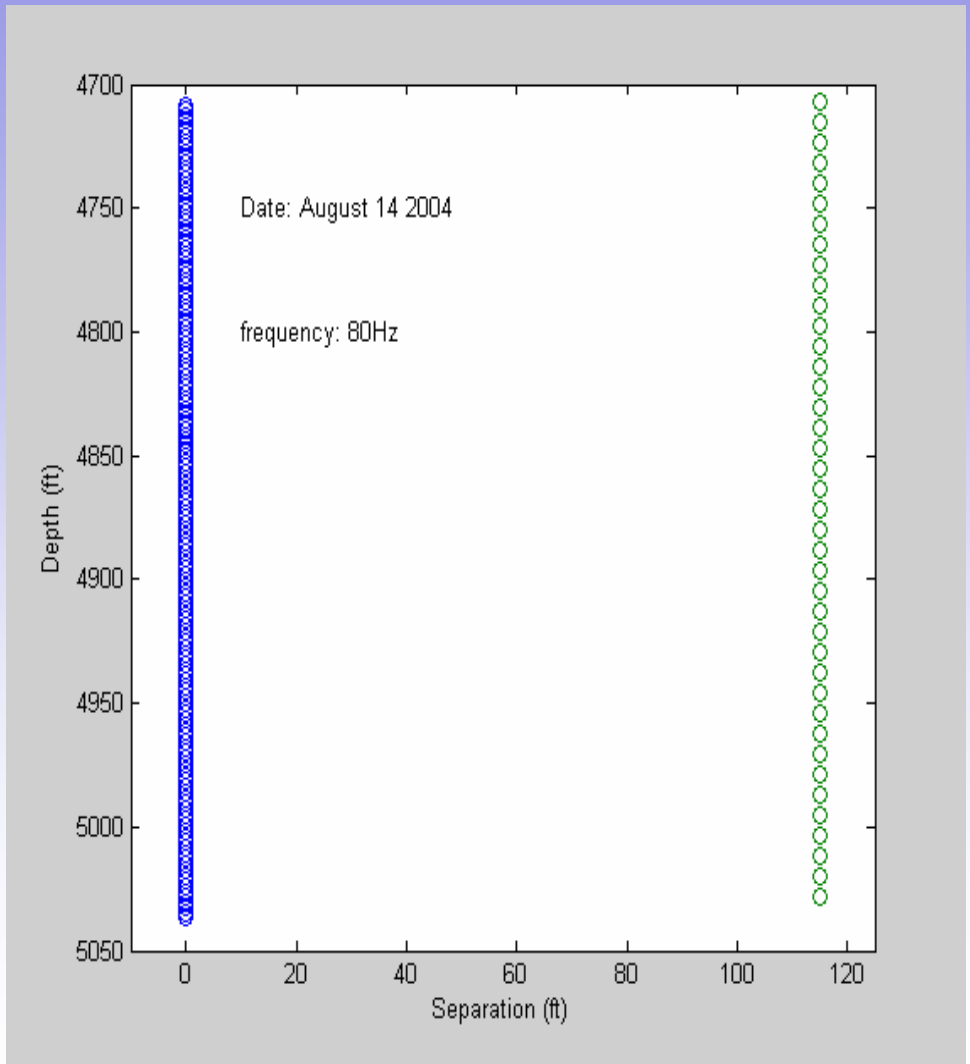
Survey Challenges

- Both wells are steel cased => Low frequency measurement.
- Well separation is close => direct signal (Primary magnetic field) much stronger than formation signal (secondary field)
- High magnetic noise

Time table

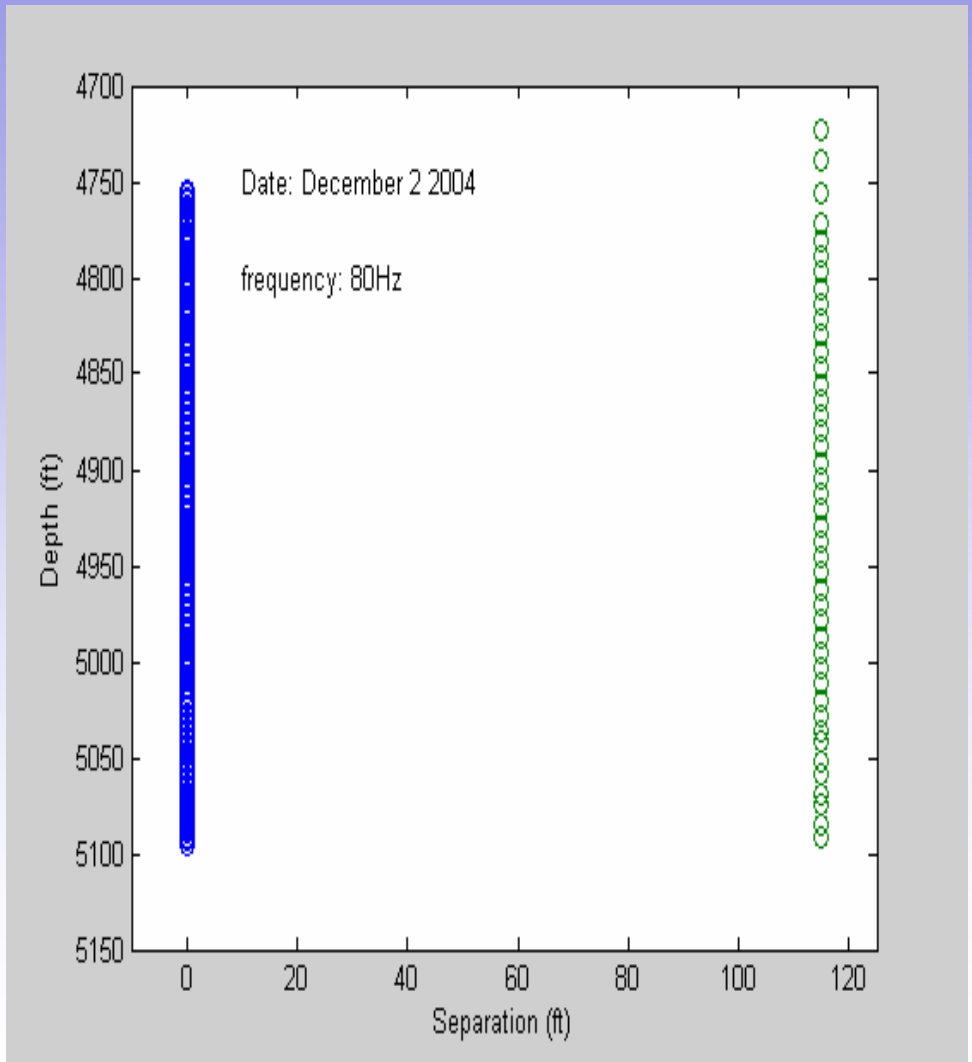
- **Aug 2004: Baseline survey**
- Sept 2004: Petrophysical model
- Oct 2004: Processing and Inversion of Baseline survey
- Nov 2004: Baseline survey reports
- **Dec 2005: Post injection Survey**
- Jan 2005: Processing and Inversion of Post Injection survey

Baseline Survey Acquisition



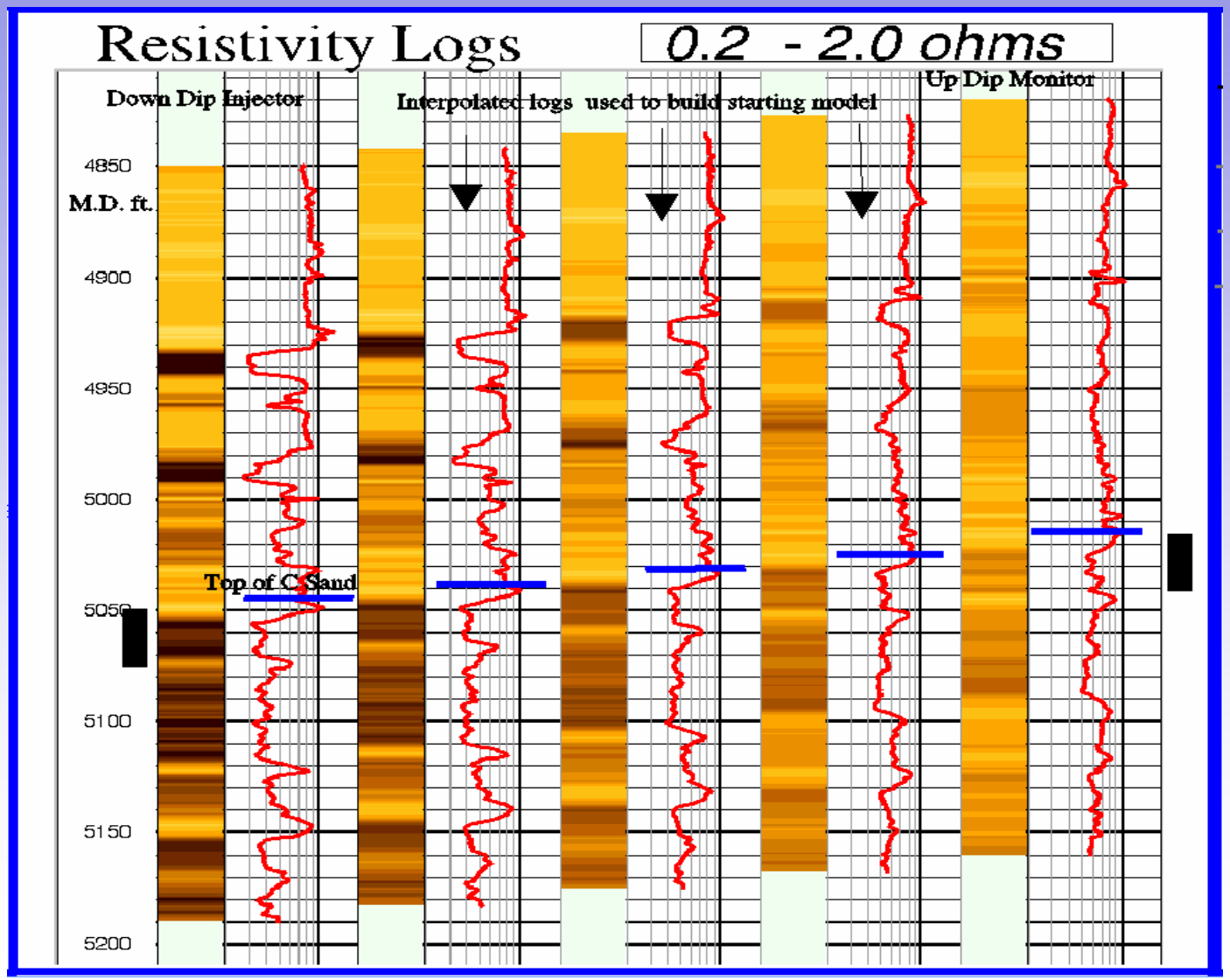
- 40 stations every 8ft between 4707ft and 5028ft (SSTVD).
- Frequency: 80Hz
- Stacking: 1000
- Logging time: 8Hrs

Post Injection Survey Acquisition

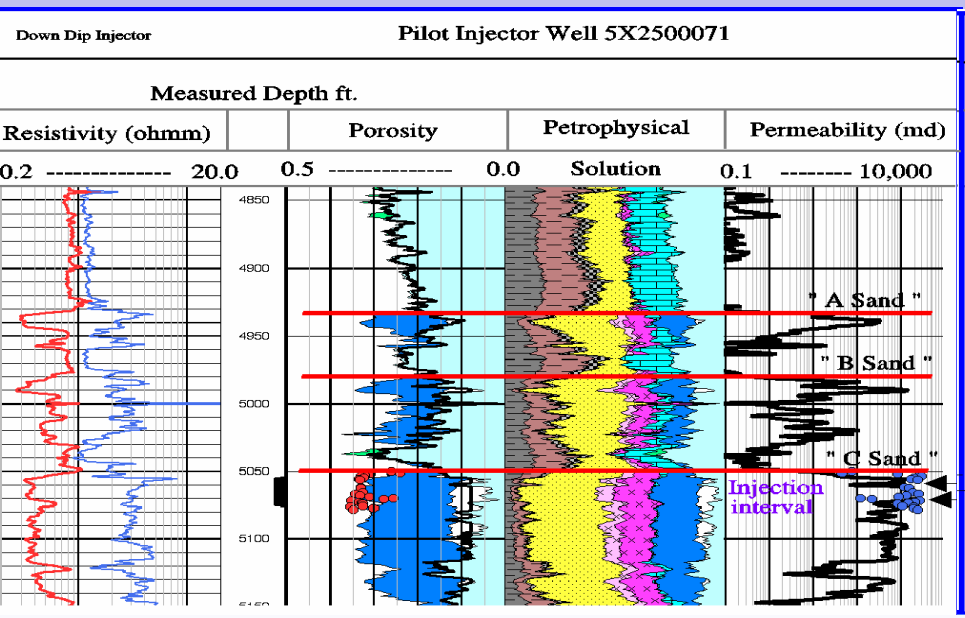


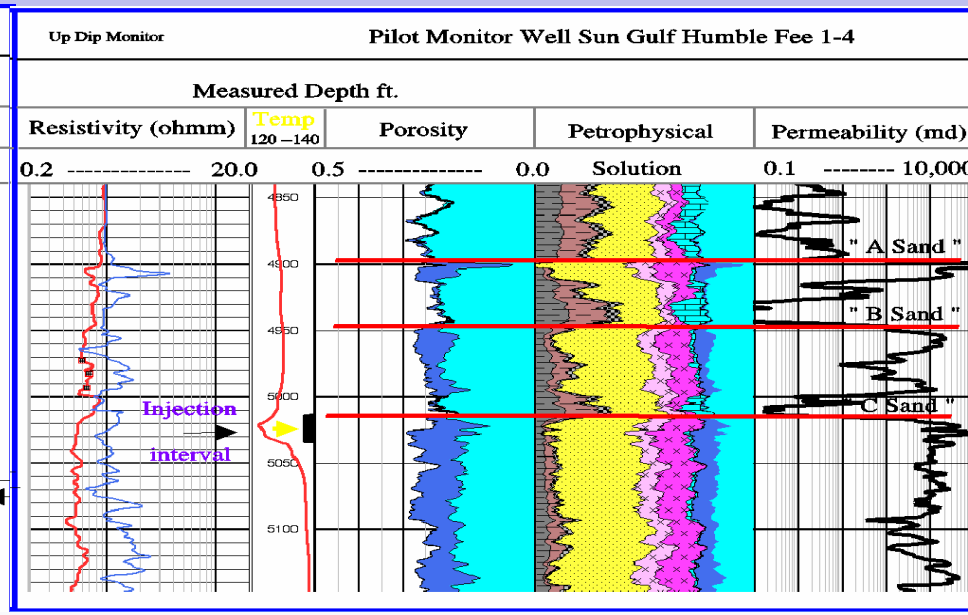
- 44 stations every 8ft between 4723ft and 5091ft (SSTVD).
- Frequency: 80Hz
- Stacking: 1600
- Logging time: 20Hours

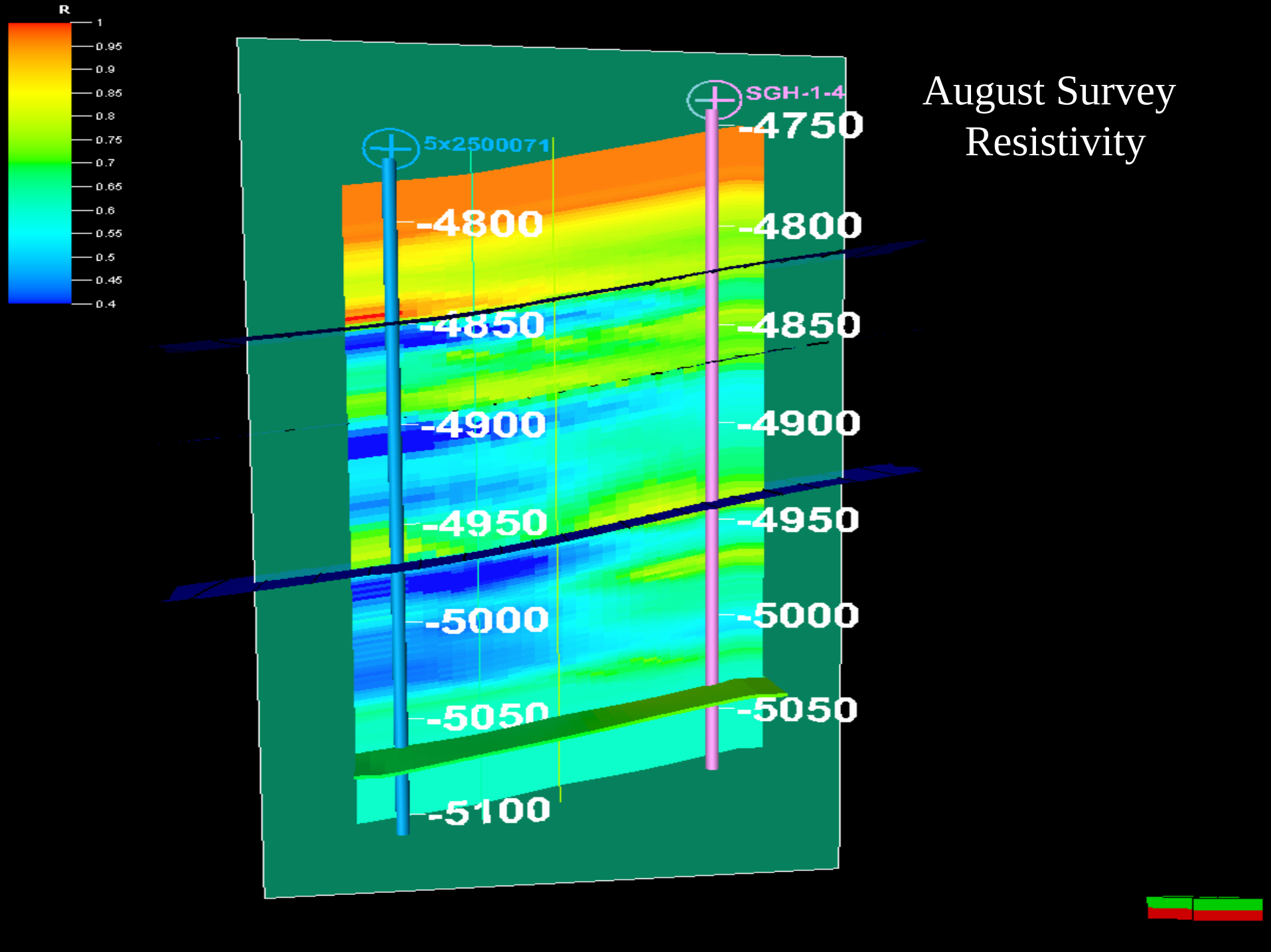
Resistivity Model



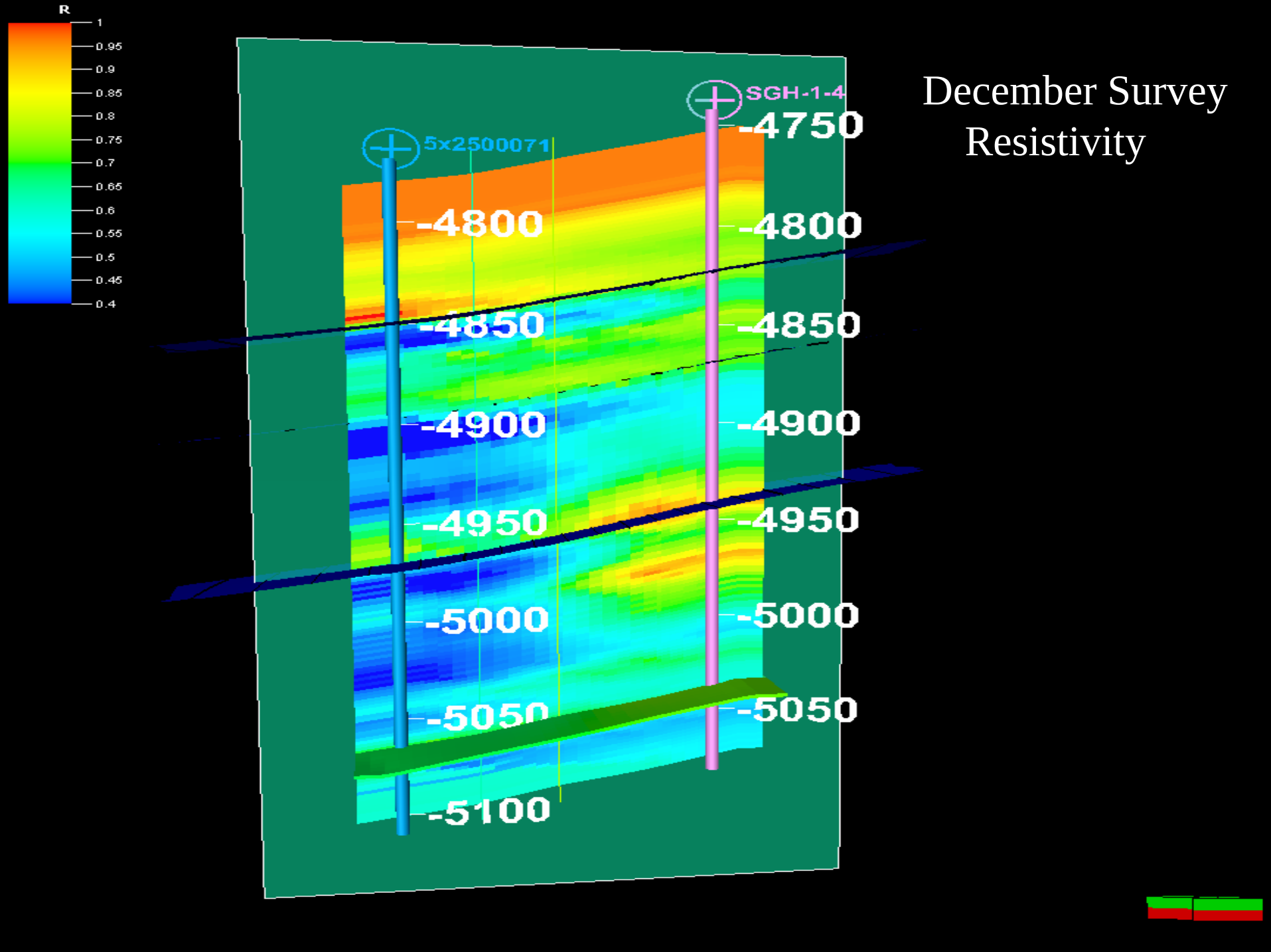
Petrophysical Model
Well Profile





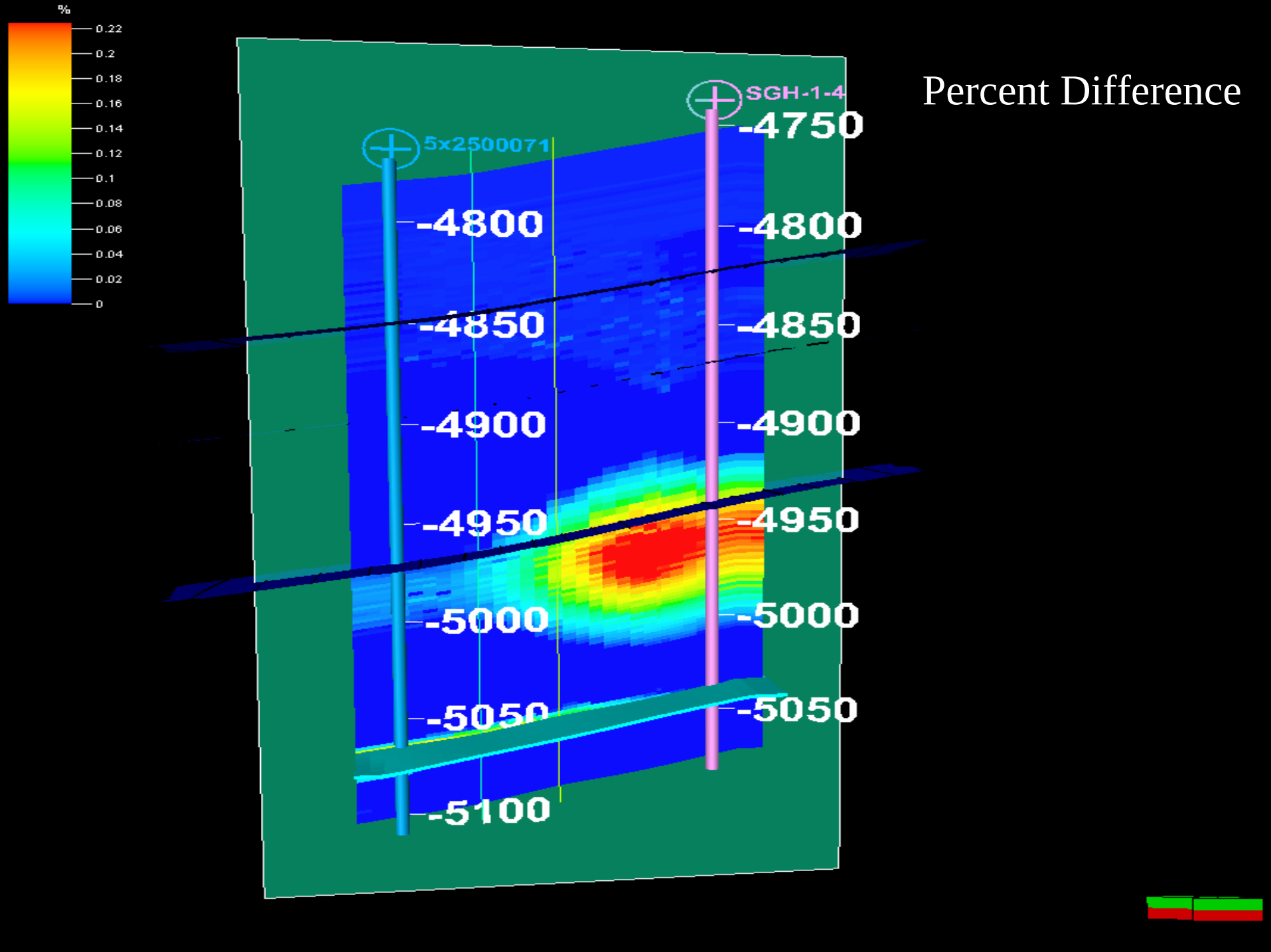


August Survey
Resistivity

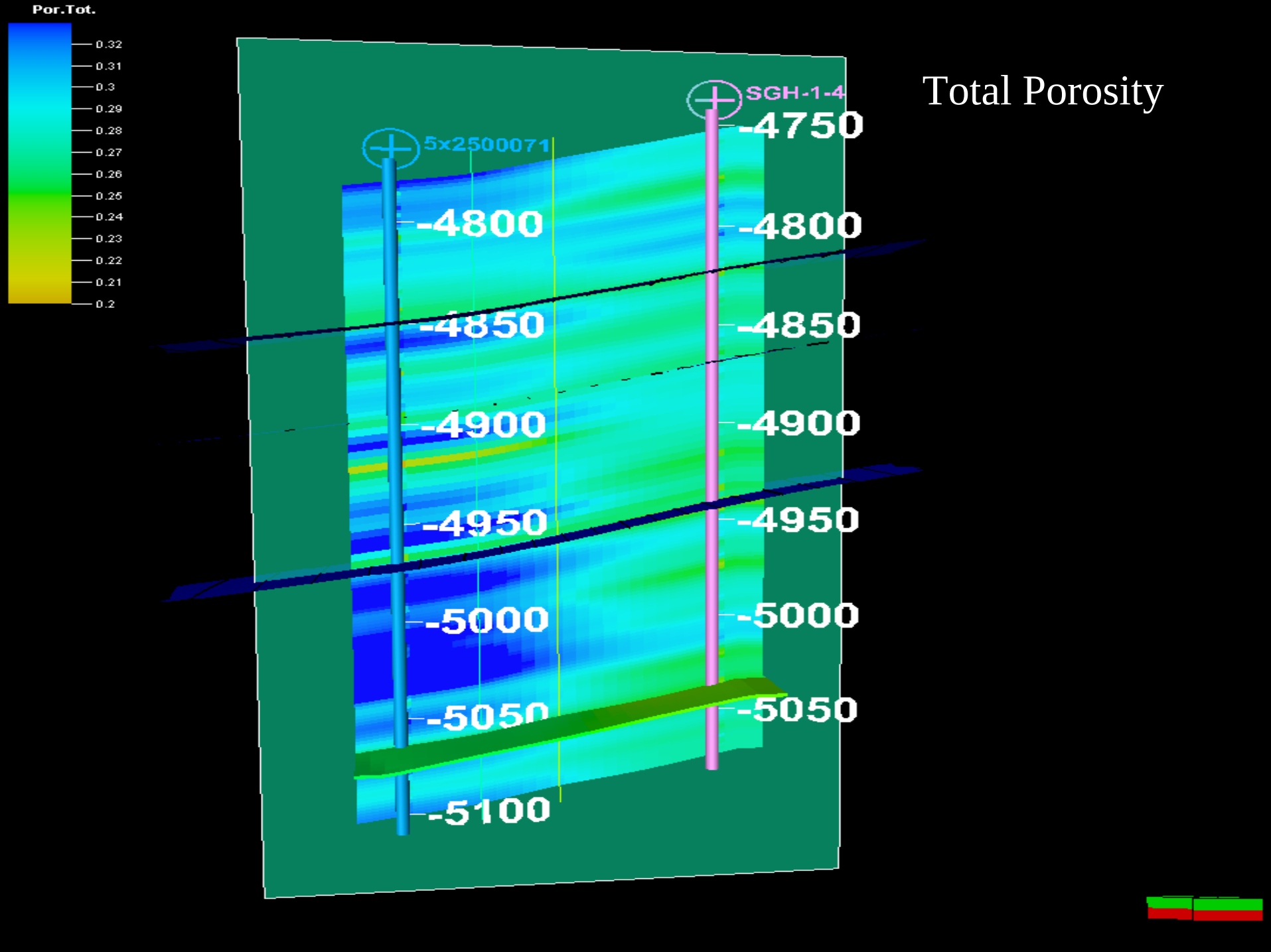


December Survey
Resistivity

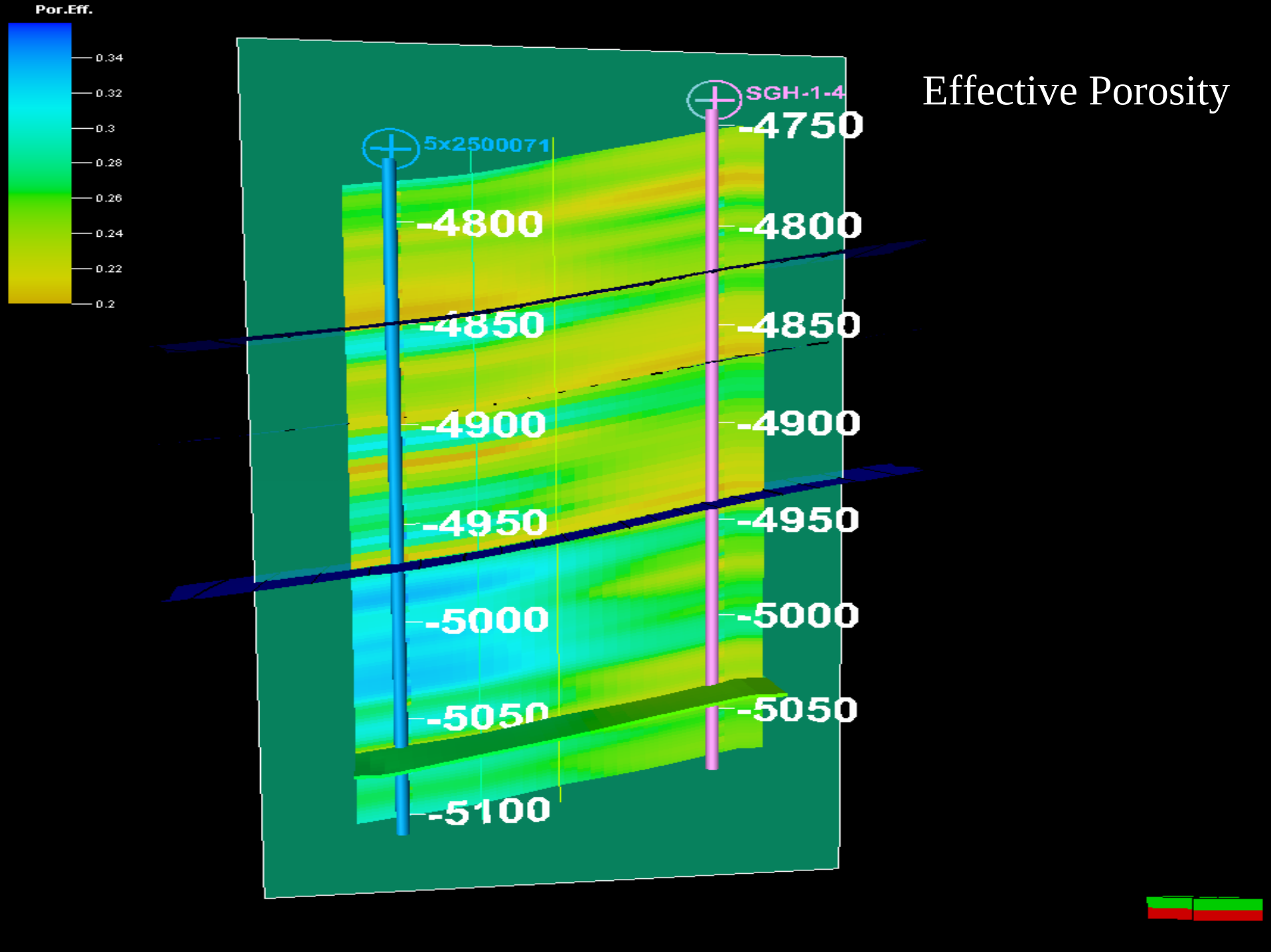
Percent Difference



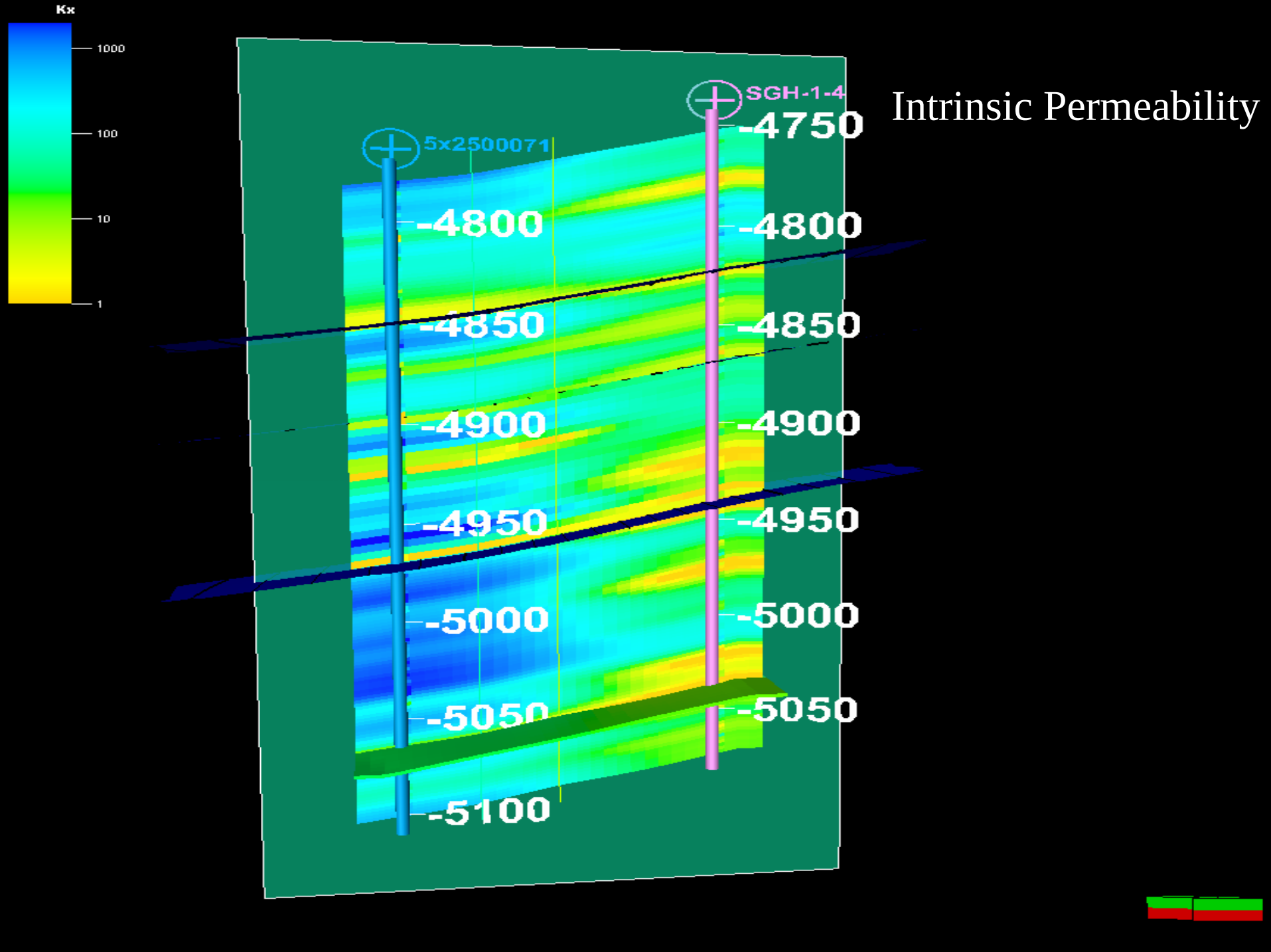
Total Porosity

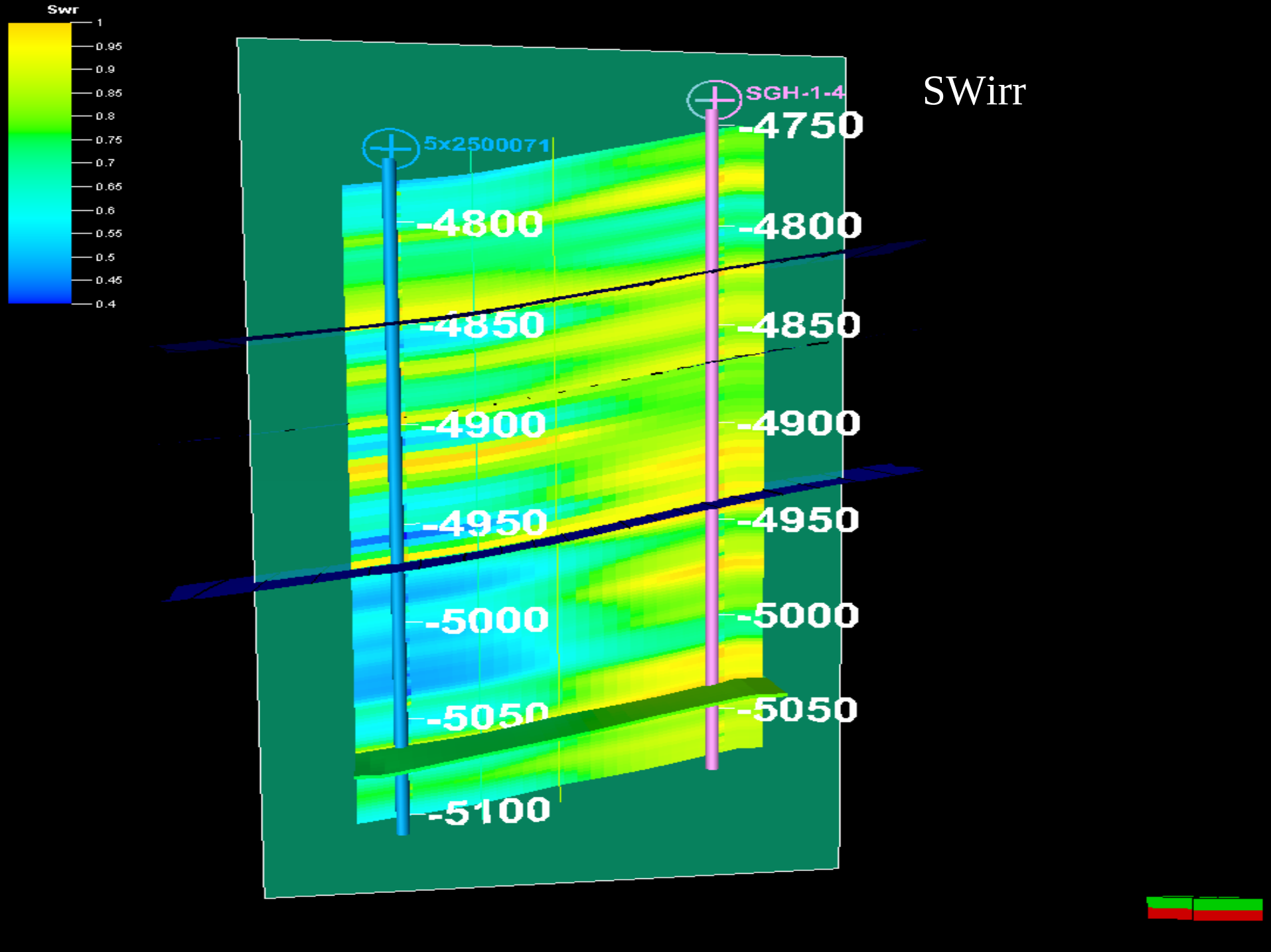


Effective Porosity



Intrinsic Permeability




Swr
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0.7
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0.6
0.55
0.5
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5x2500071
SGH-1-4
-4750
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-4850
-4900
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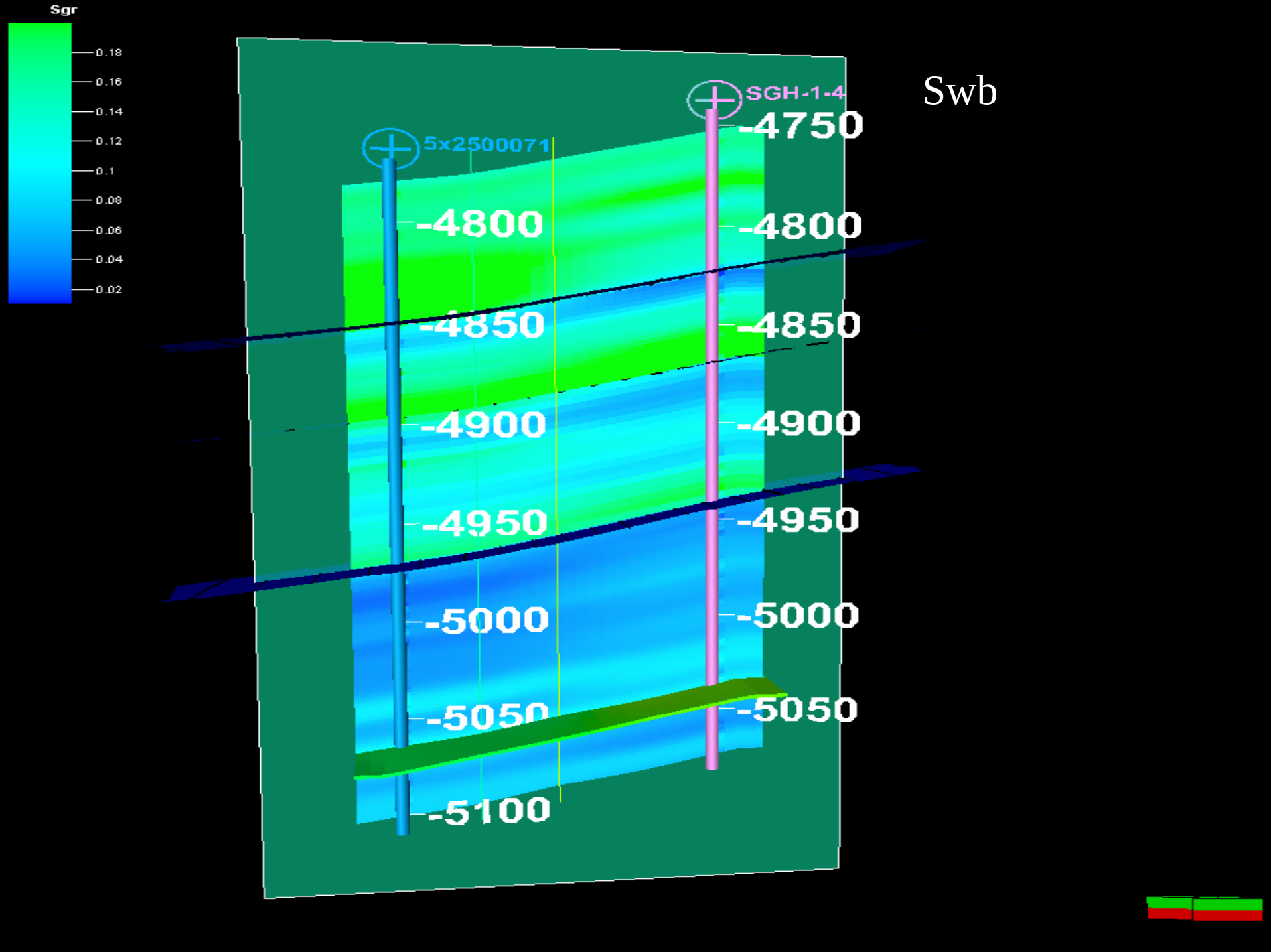
-5000
-5050
-5100
SWirr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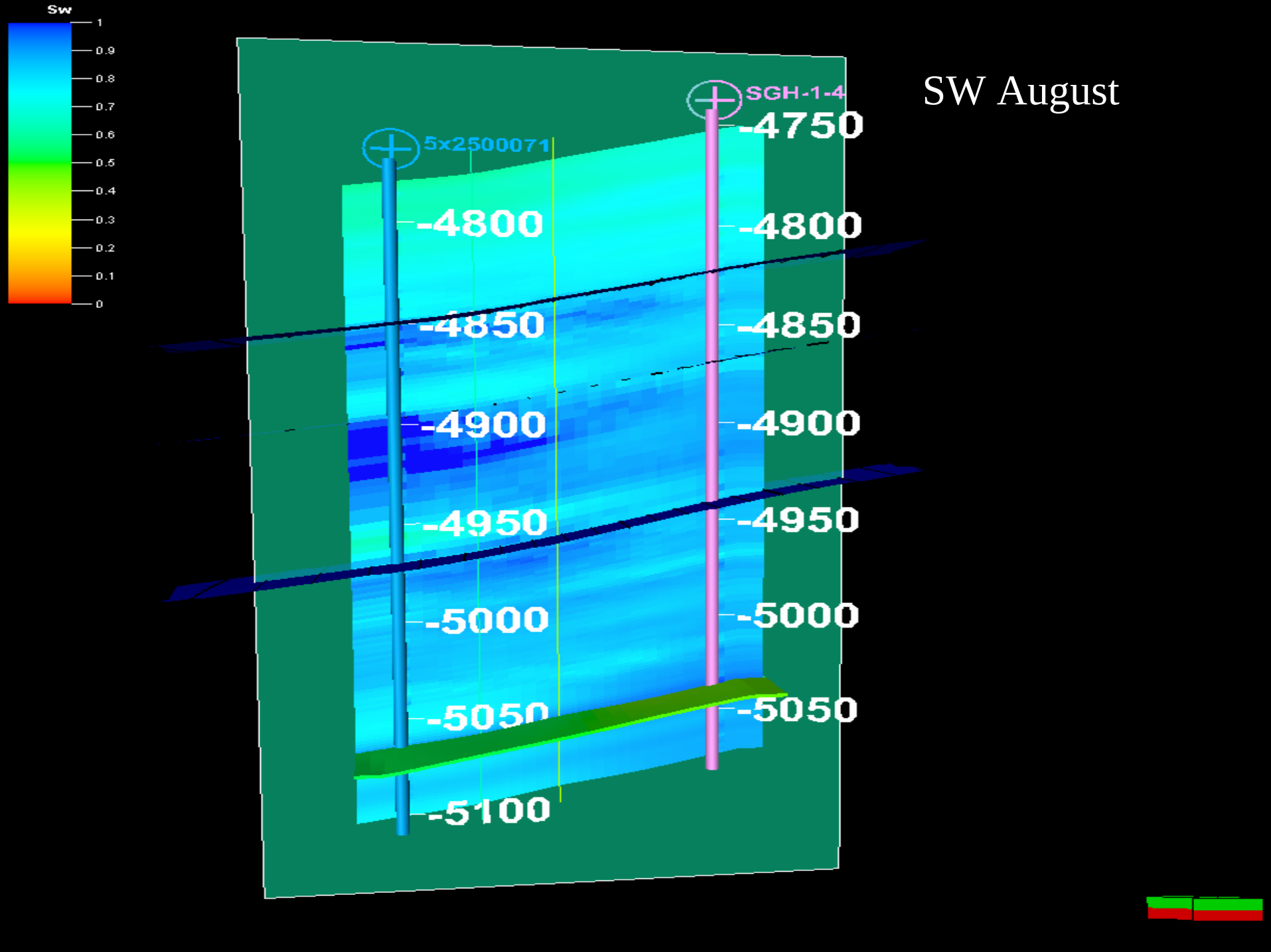
-5000
-5050
-5100
Swb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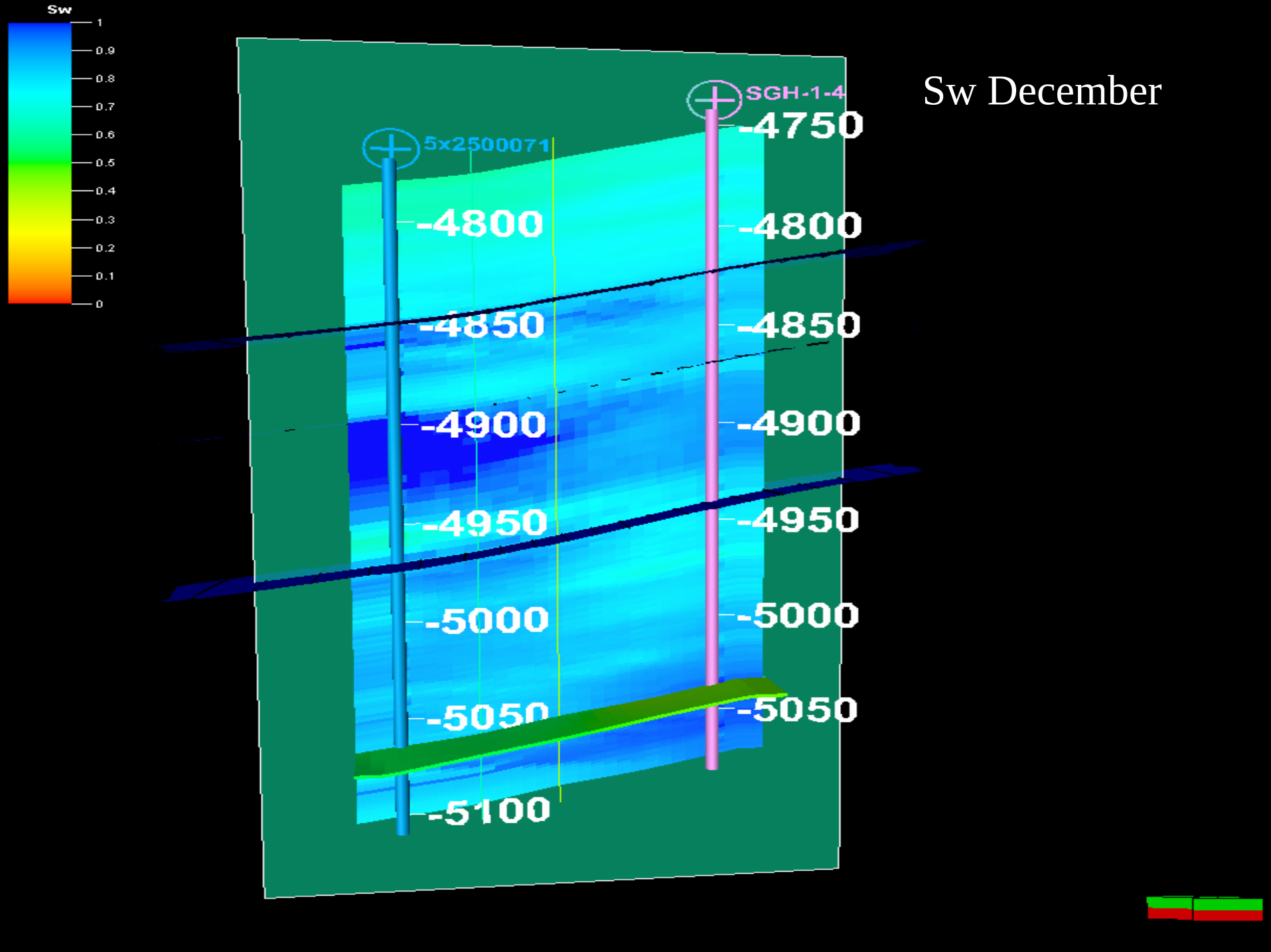
SW August


Sw December
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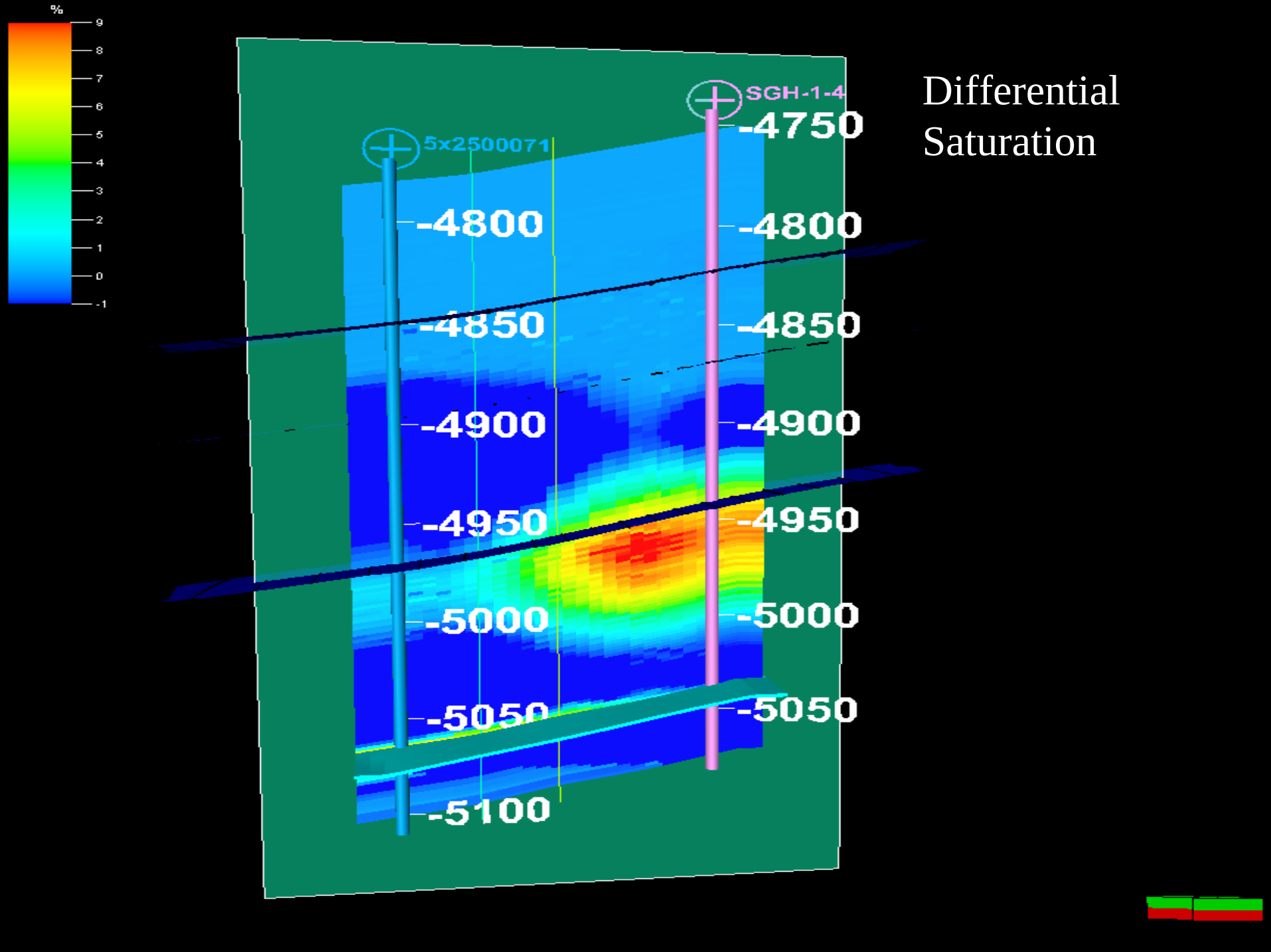
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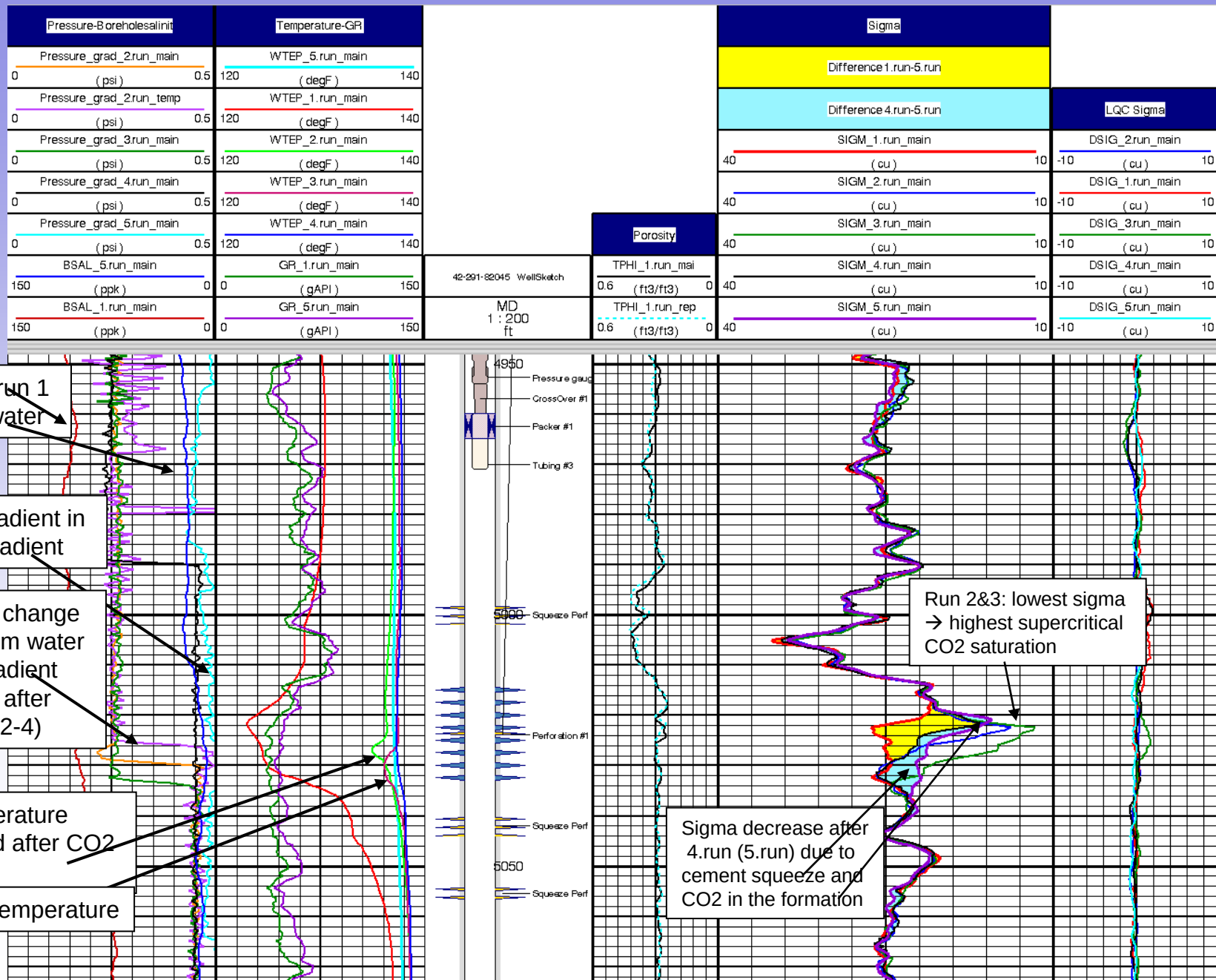
-5100
Differential
Saturation

1.-5.run



Schlumberger

Post Injection Survey Results

- Data reprocessed (including baseline) for better depth matching using RST logs.

- Data inversion using resistivity statistical constraints (boundaries).

Seismic Crosswell: Acquisition Details

- 40 3-component sensors at 25 ft. spacing per shot
- 5 source 'fans' interleaved to give 5 ft. source and sensor spacing
- 250 ft. per source fan, approximately centered on reservoir
- Orbital vibrator source gives both P- and S-wave energy (in-line and cross-line source components)
- Source frequency content ~ 70 Hz to 350 Hz

Seismic Crosswell

- Combination of 3-component sensors and 2-component source gives 6-component data
- Pre Injection Survey: July, 2004
- Post Injection Survey: Nov. 28, 2004
- Both wells perferations were cemented during both surveys

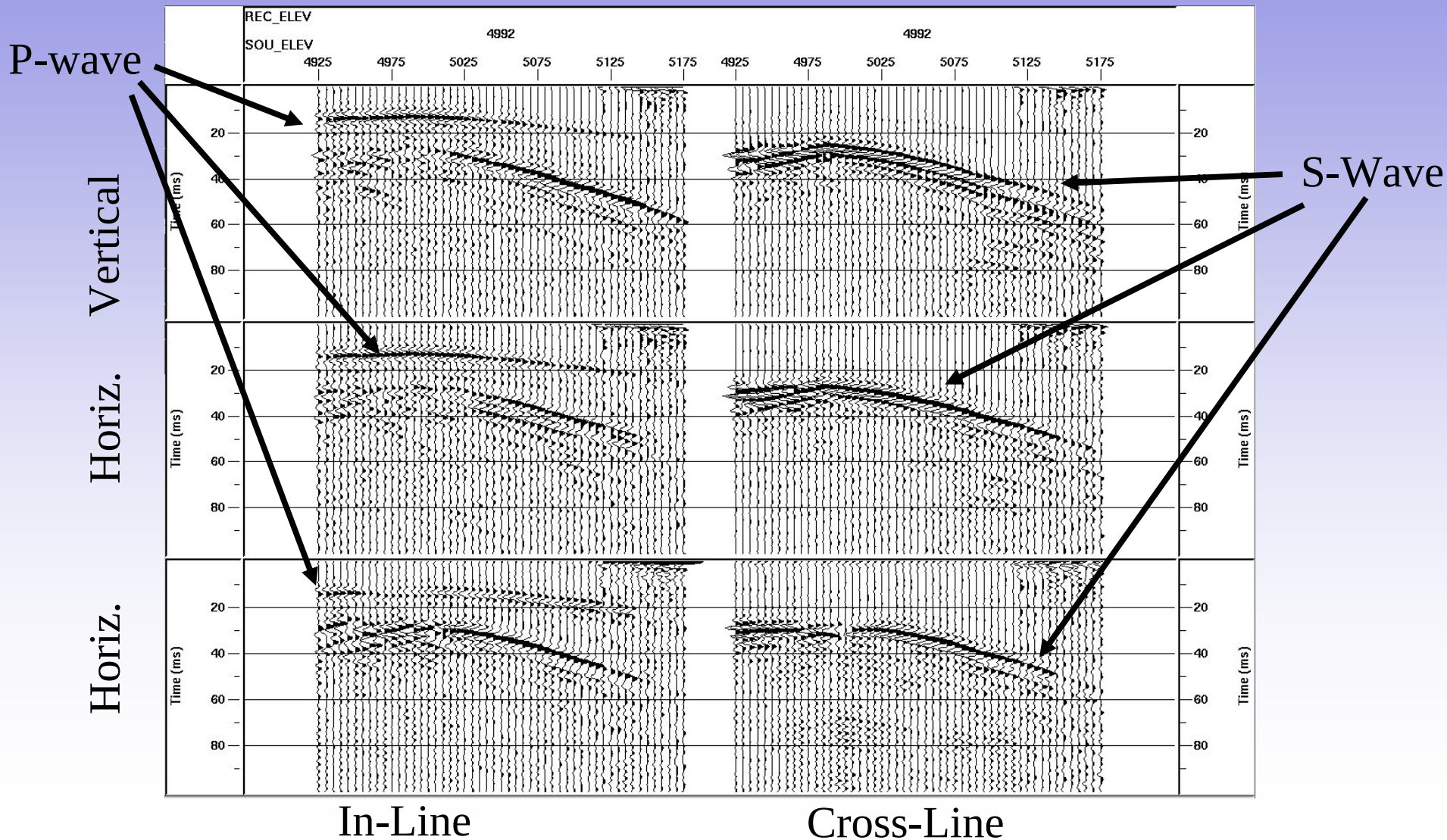
LBNL Recording Truck, Paulsson Sensor Cable on Reel, LBNL Source Wireline

LBNL Orbital Vibrator Borehole Seismic Source

Operating principle is a spinning eccentric mass controlled by an electric motor.

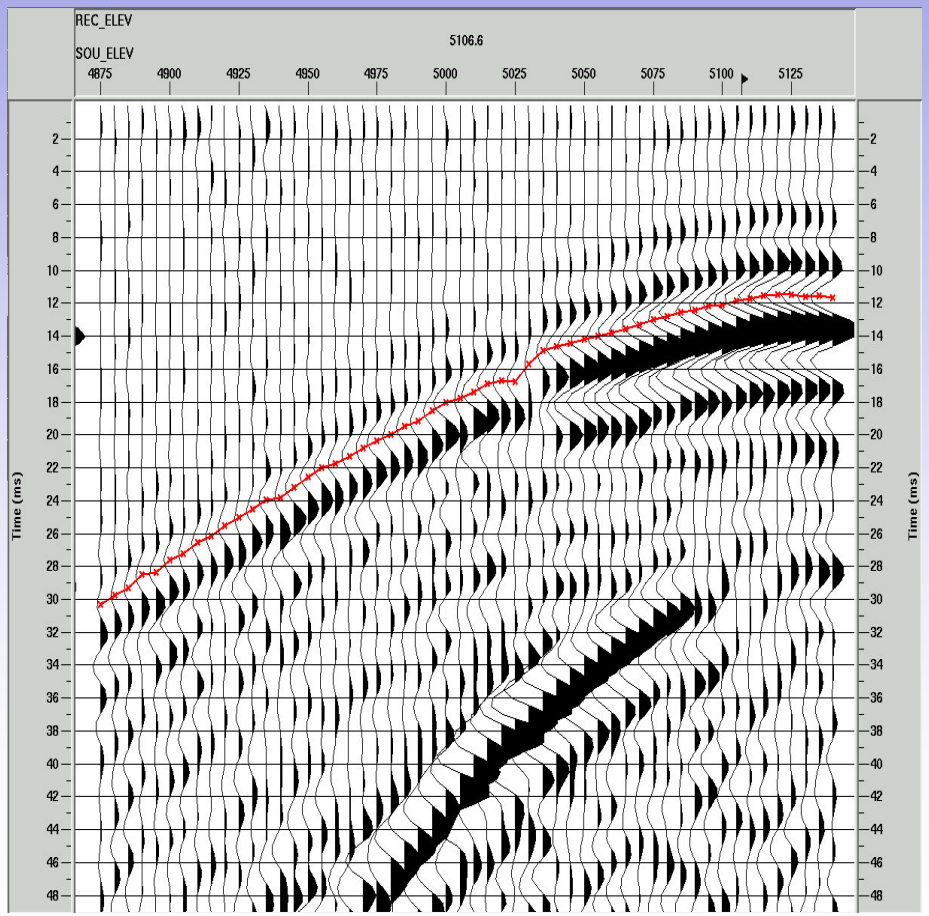
Seismic Crosswell – Raw Data
6-Component O.V. Receiver Gather at 4992'

In-Line (left) has P and SV; Cross-Line (right) has SH

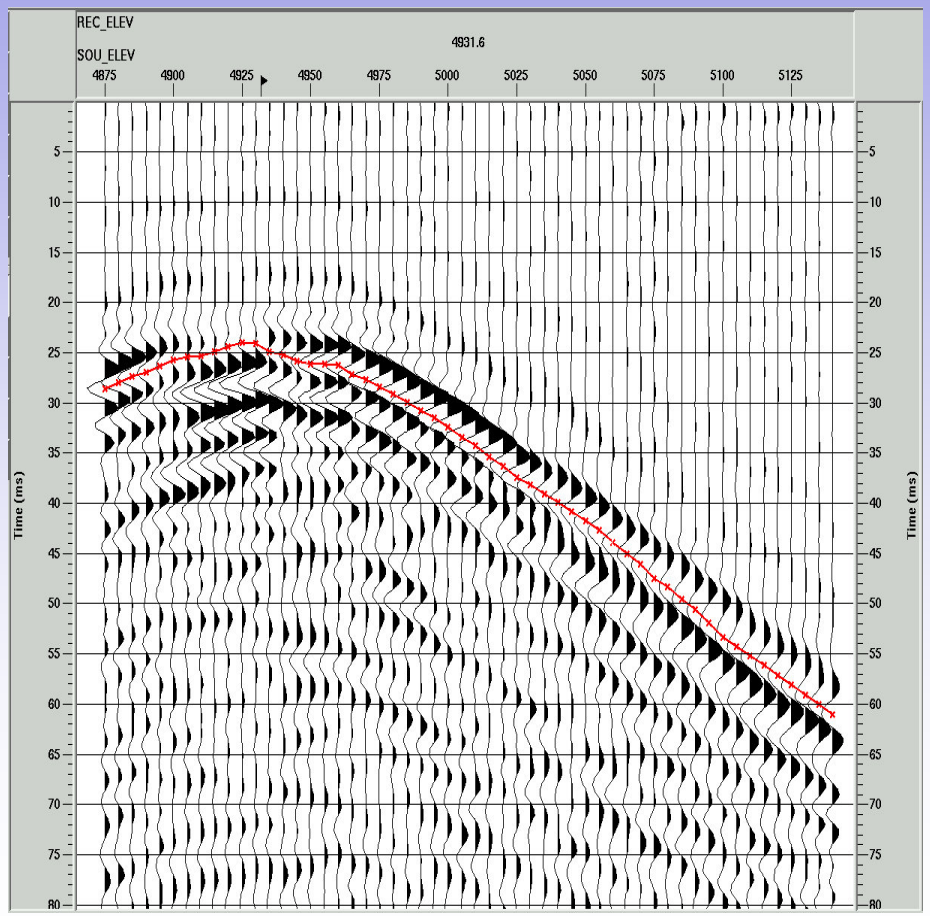


Example Crosswell Time Picks

P-Wave



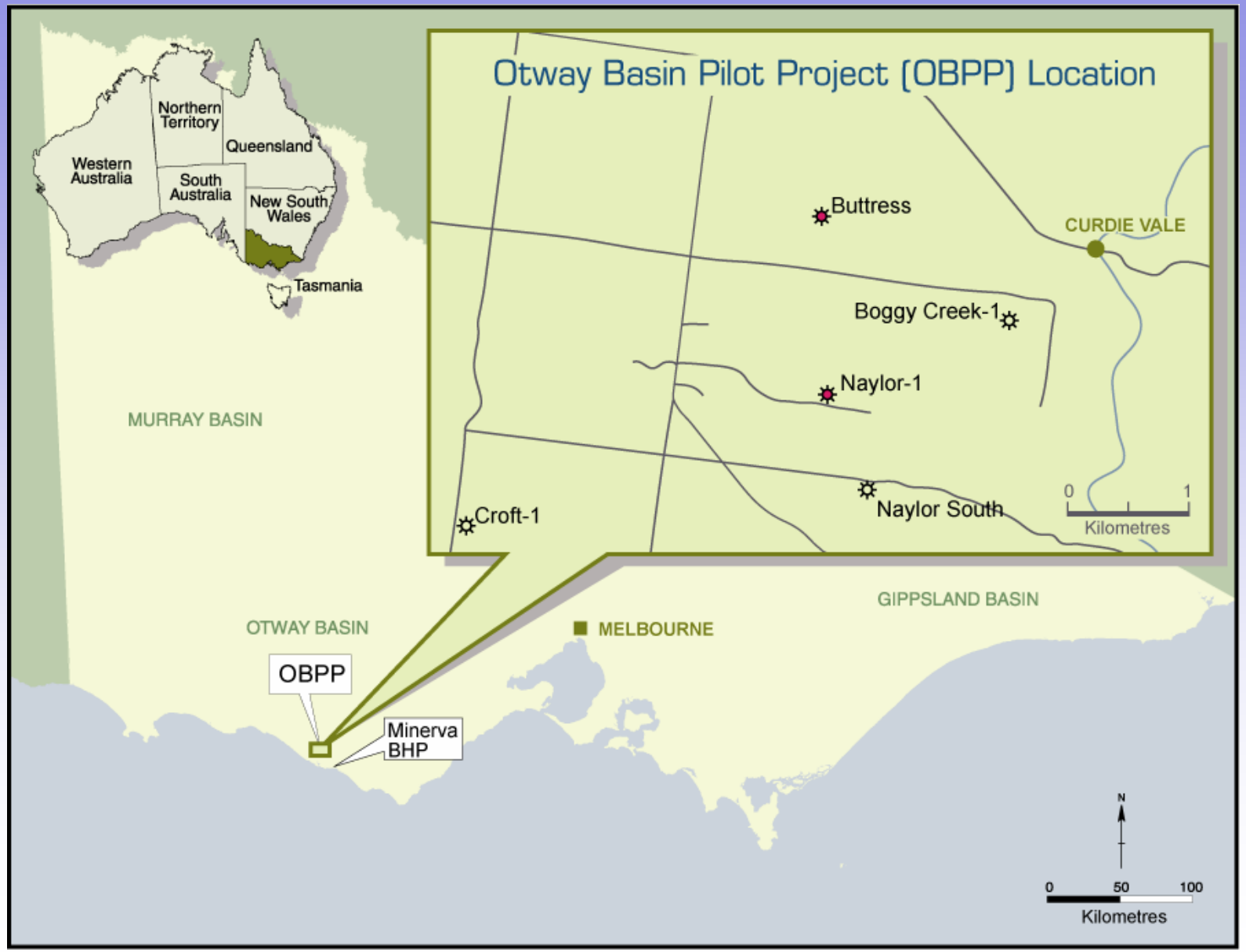
S-Wave



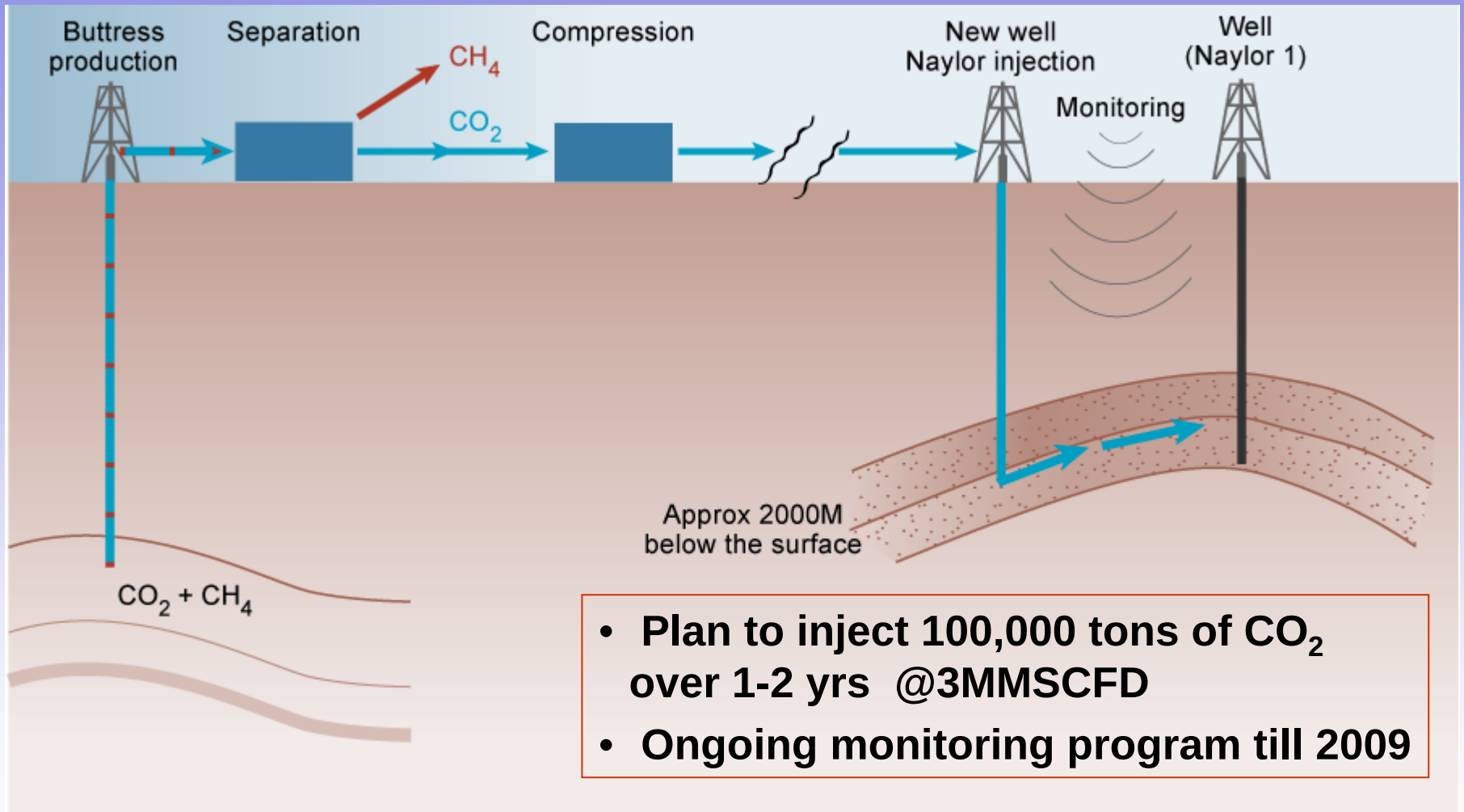
Seismic Crosswell - Acknowledgments

- Data acquisition by LBNL
- Unique 3-component geophone sensor string provided with support of Paulsson Geophysical
- Seismic source provided by LBNL
- Field support by Sandia Technologies

CO2CRC Pilot Project



Conceptual Representation of Pilot Project



- **Plan to inject 100,000 tons of CO_2 over 1-2 yrs @3MMSCFD**
- **Ongoing monitoring program till 2009**

Wells and Facilities

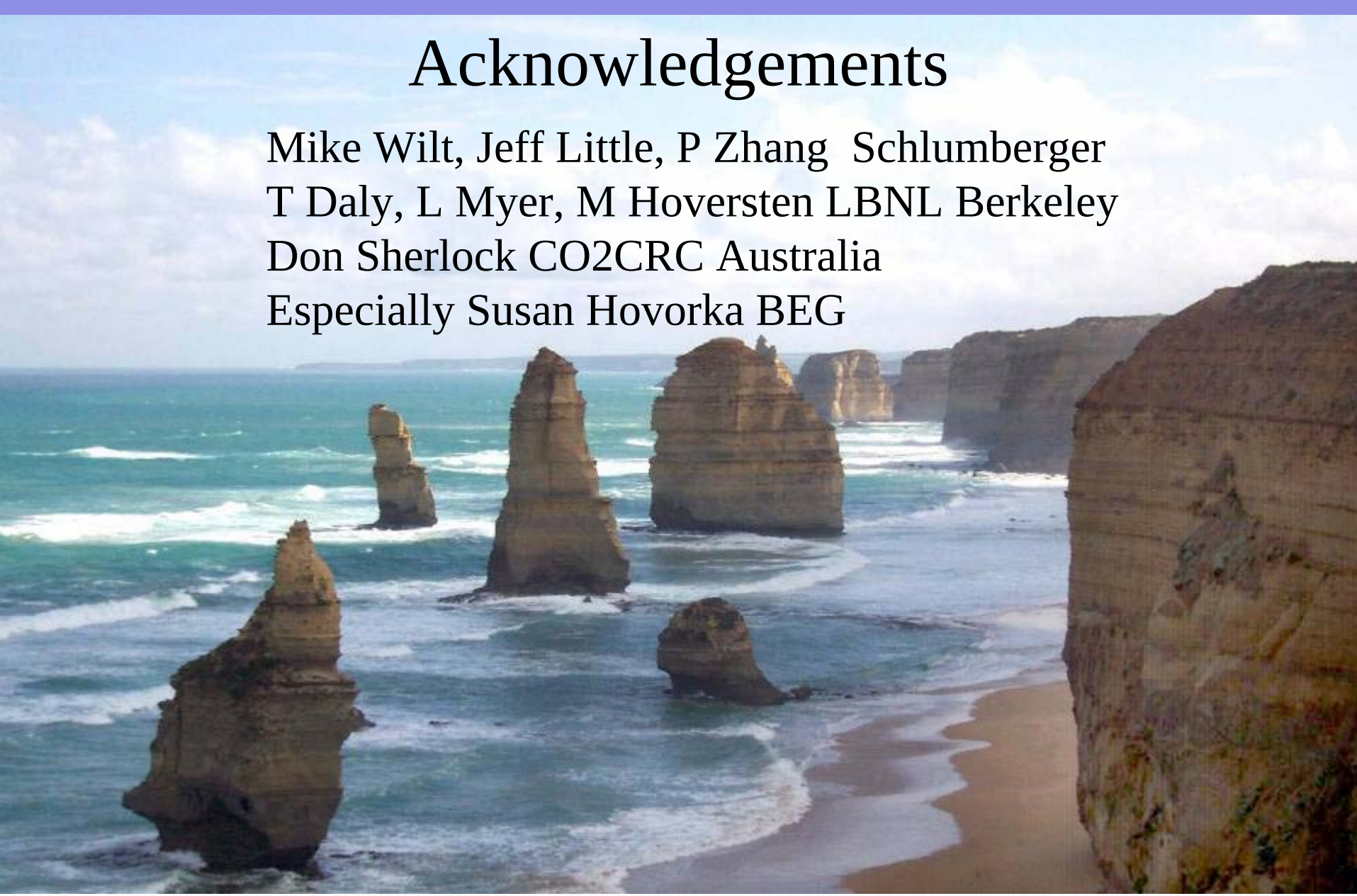
Reservoir/Well Status

Buttress:

- Reservoir gas is high CO_2 content: 85-92%
- Most likely reserves 250Mt of CO_2
- Buttress-1 completed with 13 Cr 3 ½ in casing (tubingless completion)
- Not perforated

Naylor:

- Depleted gas field (recovered 4 Pj from 8 Pj GIP)
- Naylor-1 completed with 13 Cr 3 ½ in casing (tubingless completion)

Acknowledgements

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T Daly, L Myer, M Hoversten LBNL Berkeley
Don Sherlock CO2CRC Australia
Especially Susan Hovorka BEG