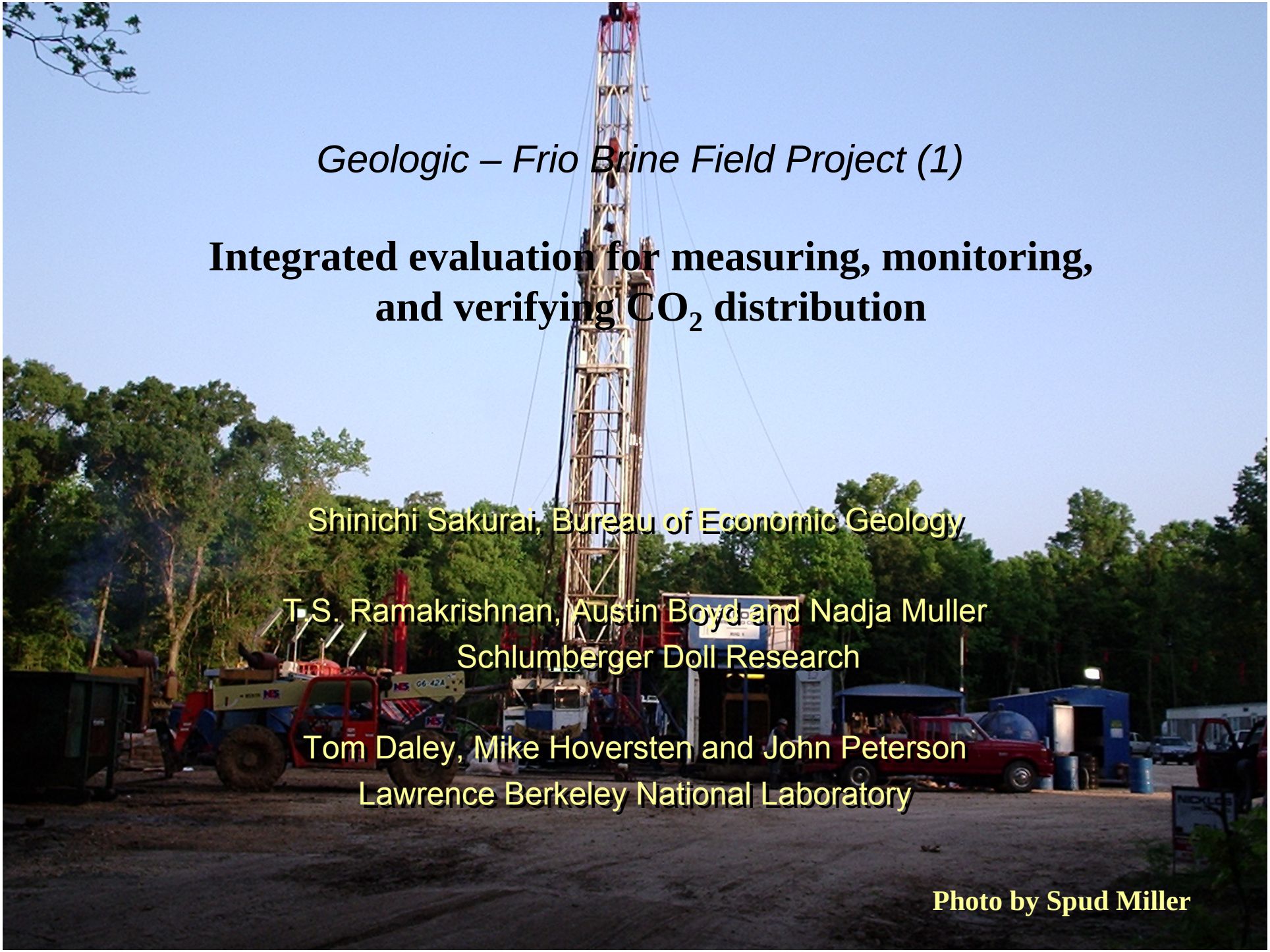


Geologic – Frio Brine Field Project (1)

Integrated evaluation for measuring, monitoring, and verifying CO_2 distribution

Shinichi Sakurai, Bureau of Economic Geology

T.S. Ramakrishnan, Austin Boyd and Nadja Muller
Schlumberger Doll Research

Tom Daley, Mike Hoversten and John Peterson
Lawrence Berkeley National Laboratory

Photo by Spud Miller

Acknowledgements

- DOE/NETL
- Sandia Technology
- Core Laboratories, Inc
- Susan Hovorka

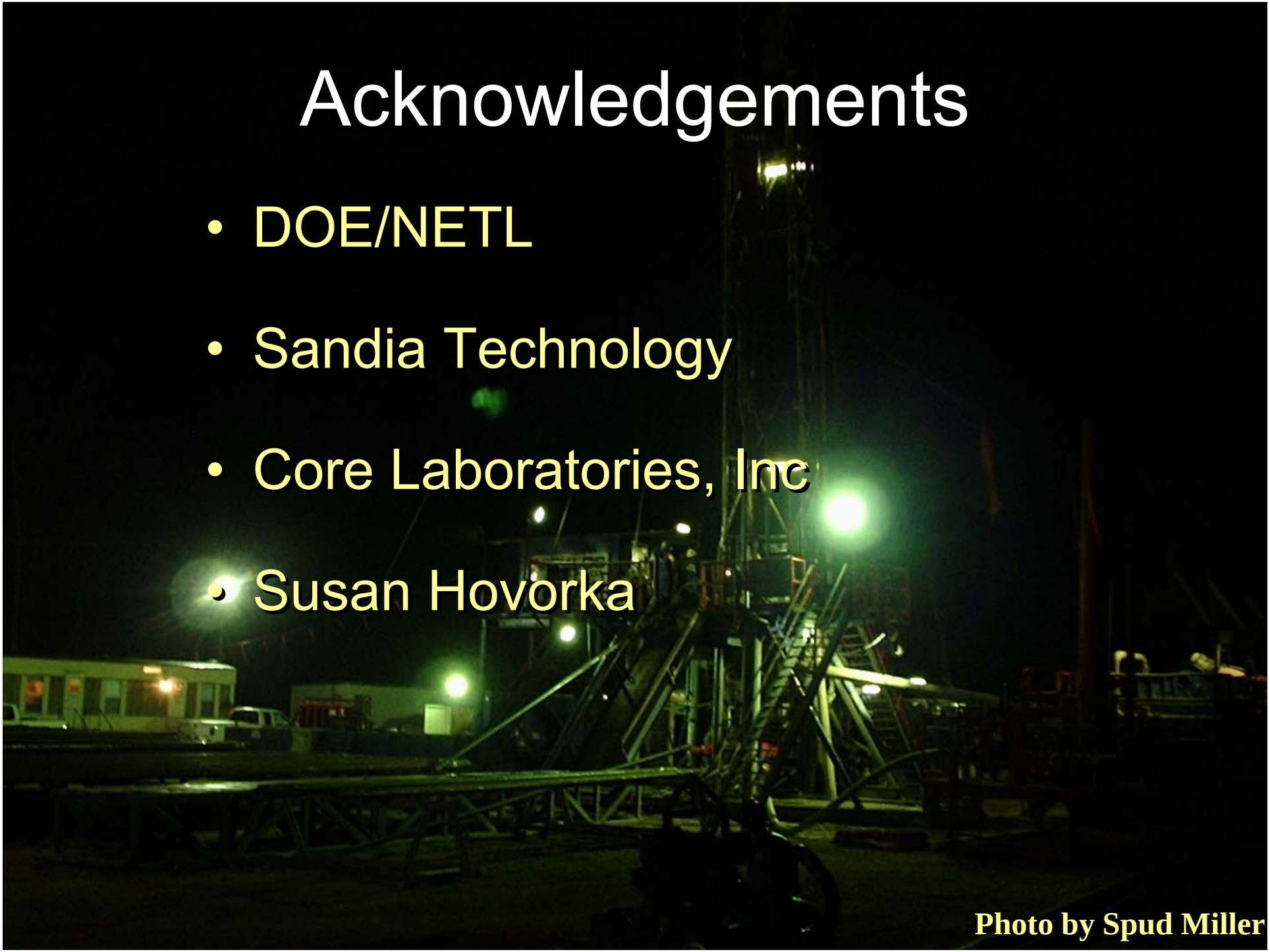


Photo by Spud Miller

Bureau of Economic Geology

Outline

- New Injection Well
  - Core & Wireline Log
- Monitor CO_2 Distribution
  - Monitor by PNC
  - Tie with Geophysics Data
- Conclusions

Photo by Spud Miller

Cores Cut and Objectives

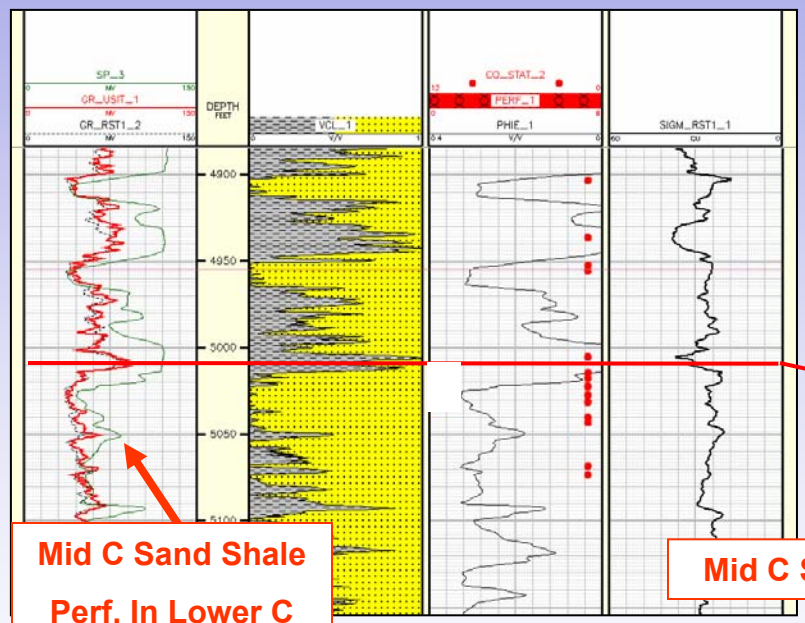
* 3 Conventional Cores Anahuac Shale	Seal Rock Property Tests by Oak Ridge, LLNL, LBNL & CSIRO
C Sand	Reservoir Quality K & Φ for Model Input CO_2 injection test
5400 ft Sand	Available for Frio II Work

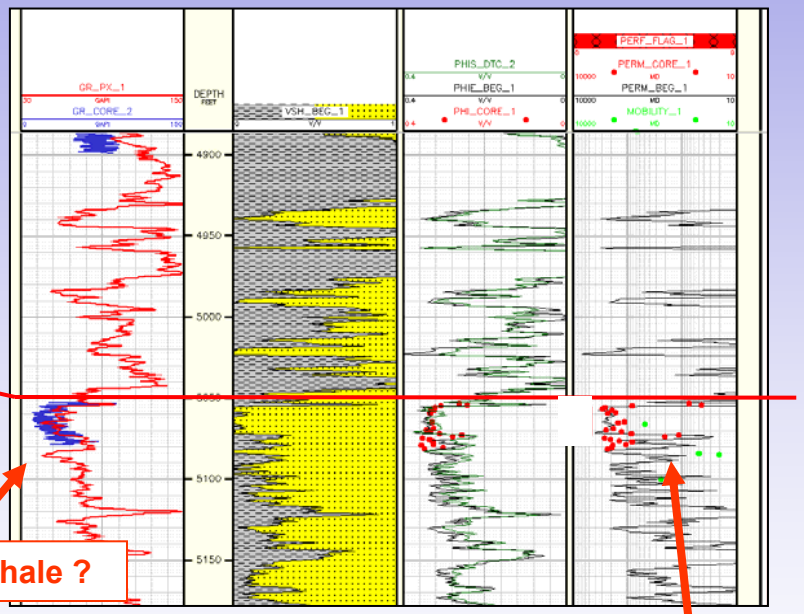
Photo by Spud Miller

Core Description & Perforation Interval

Observation Well

Injection Well





Mid C Sand Shale

Perf. In Lower C sand

Mid C Sand Shale ?

Sandy silt

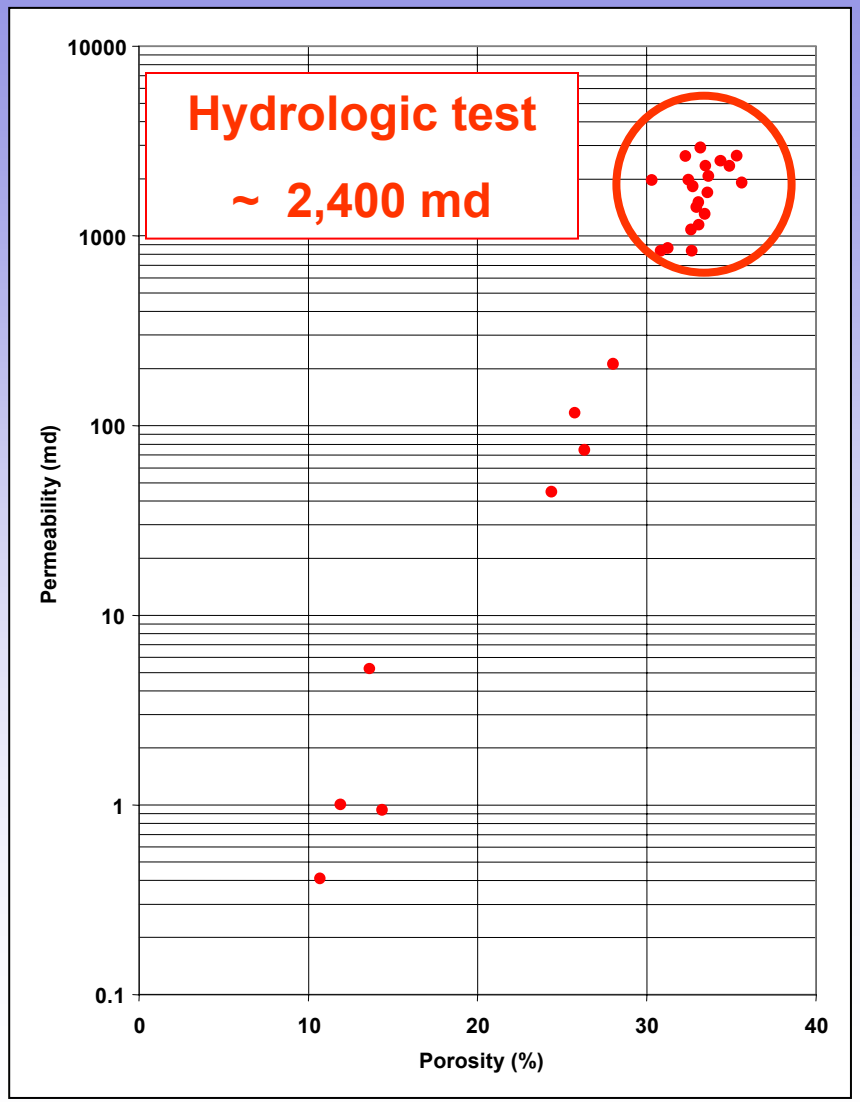
K ~ 100 md

Core Analysis & Reservoir Description

- **Understand Reservoir Quality**
  - **Old Estimates from publication**
- **Conventional Analysis made @ 1800 psi**

Update input of simulation model

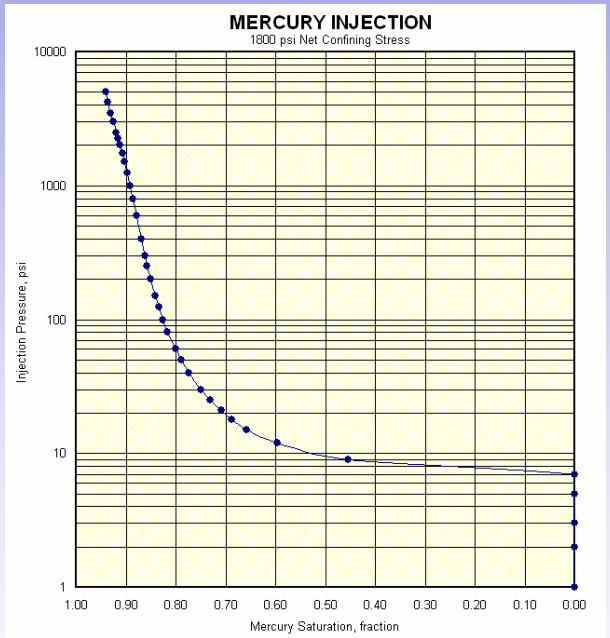
- **Higher Φ & K**
- **New perforation**



Sakurai et al., SPWLA, 2005

Special Core Analysis for Reservoir Quality

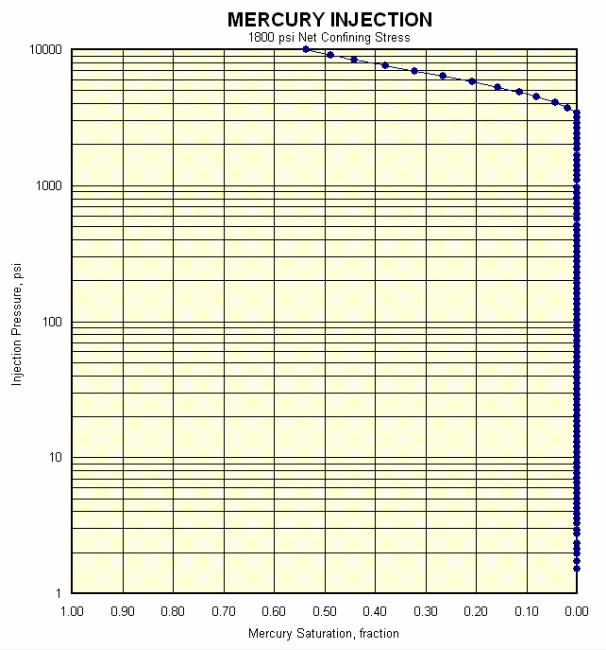
Capillary Pressure



C Sand

33. 1 %

1150 md



Anahuac Shale

Good Seal

Sakurai et al., SPWLA, 2005

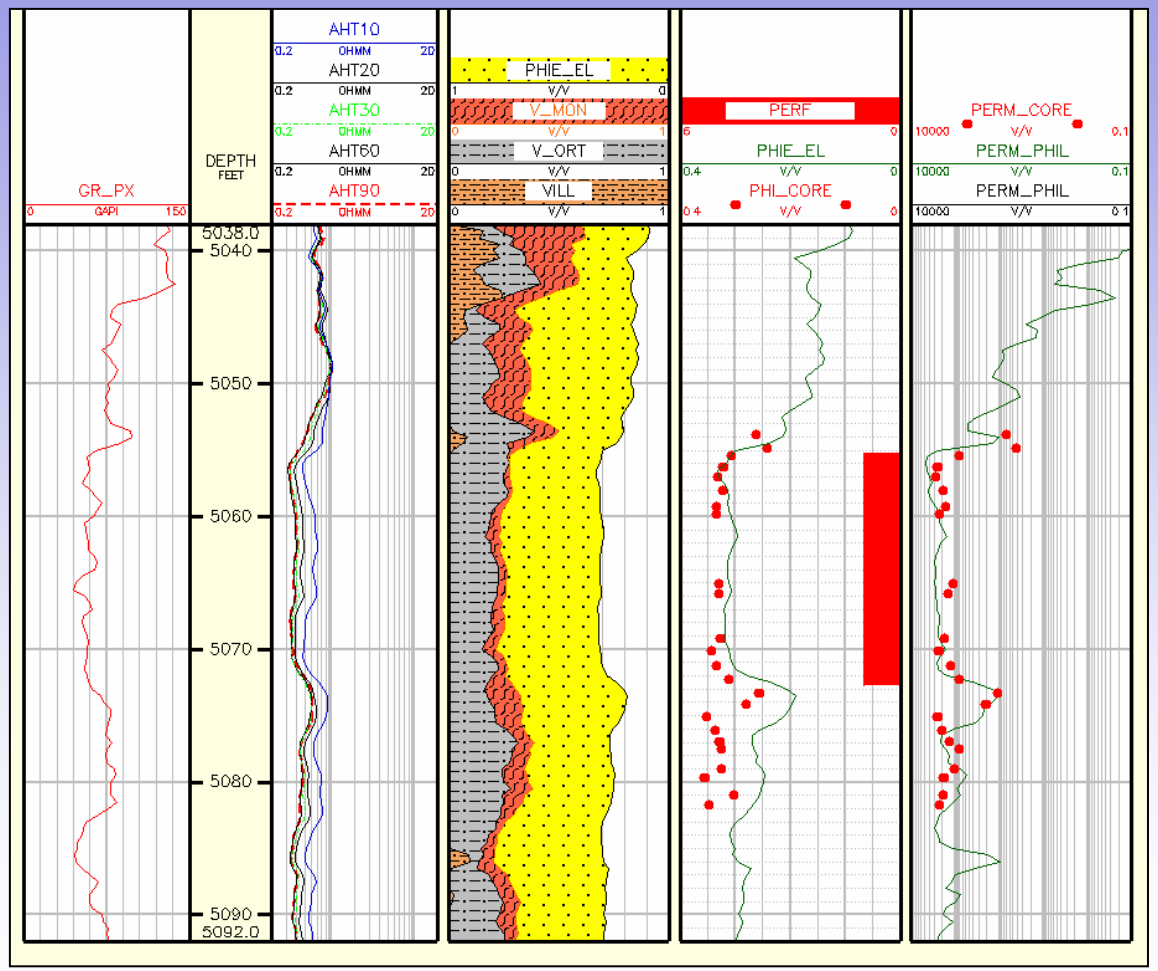
Openhole Logging

Triple Combo (Rhob, Np, AIT)
Sonic
Borehole Imager
Wireline Formation Tester

Photo by Spud Mille

Open Hole Log Analysis

With Core Data



Very High Reservoir Quality

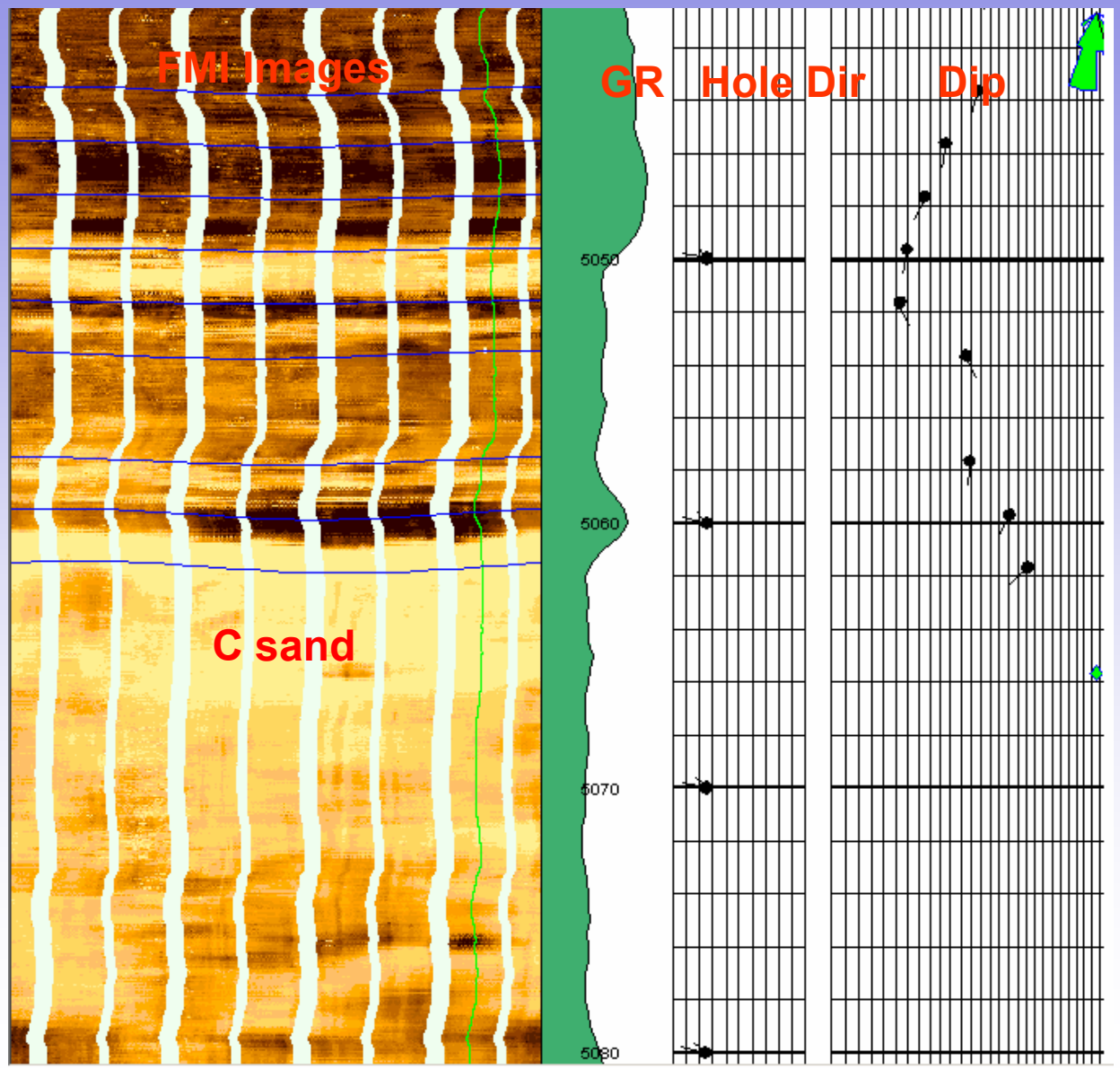
Φ 30+ %

K ~ 2000 md

Lithology agreed well with XRD

Sakurai et al., SPWLA, 2005

Formation Micro Imager
Borehole Image of Conductivity



Structure Dip

18 Degree

South

No Faults Observed

Bureau of Economic Geology

Outline

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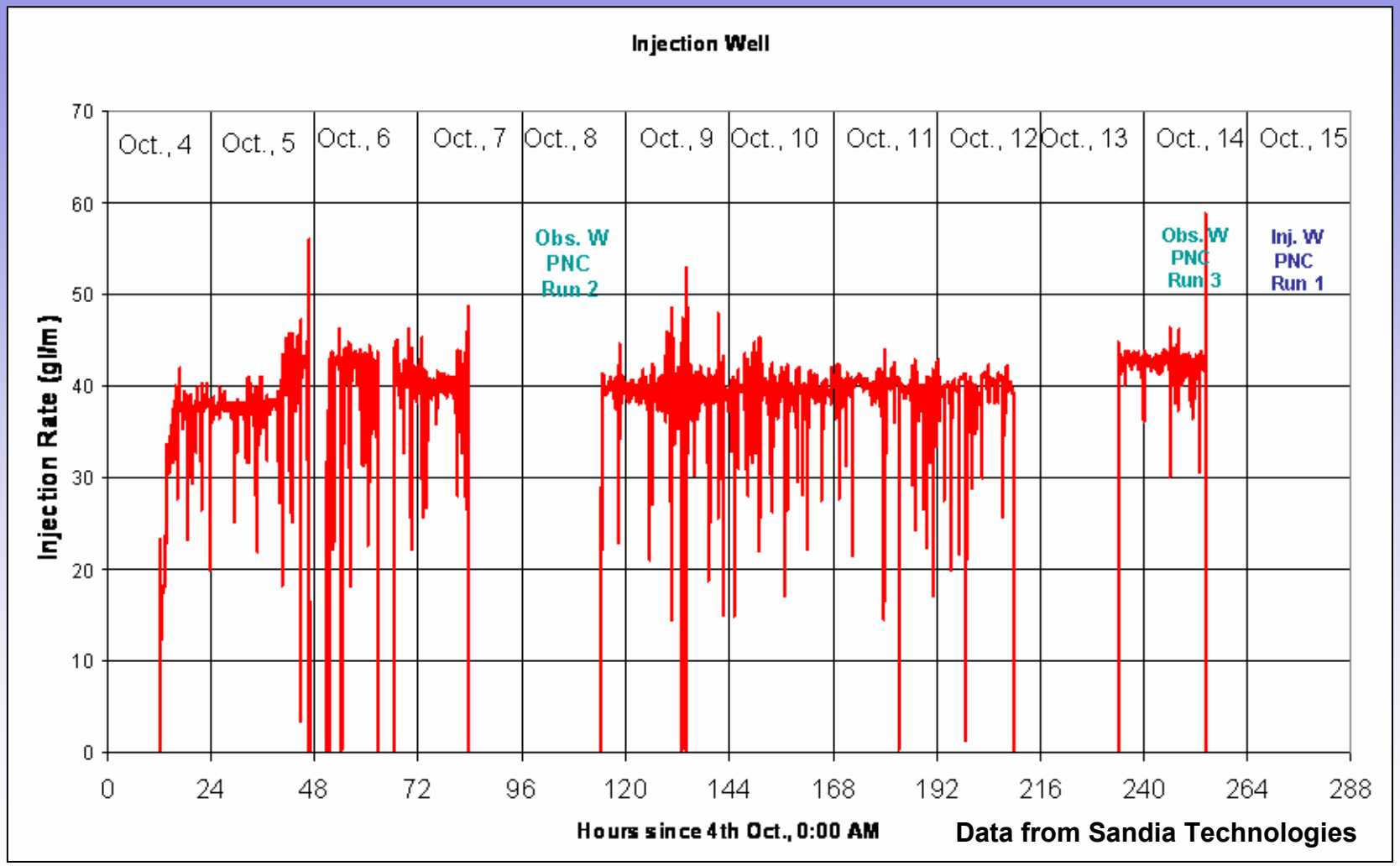
Photo by Spud Miller

CO_2 Injection rate

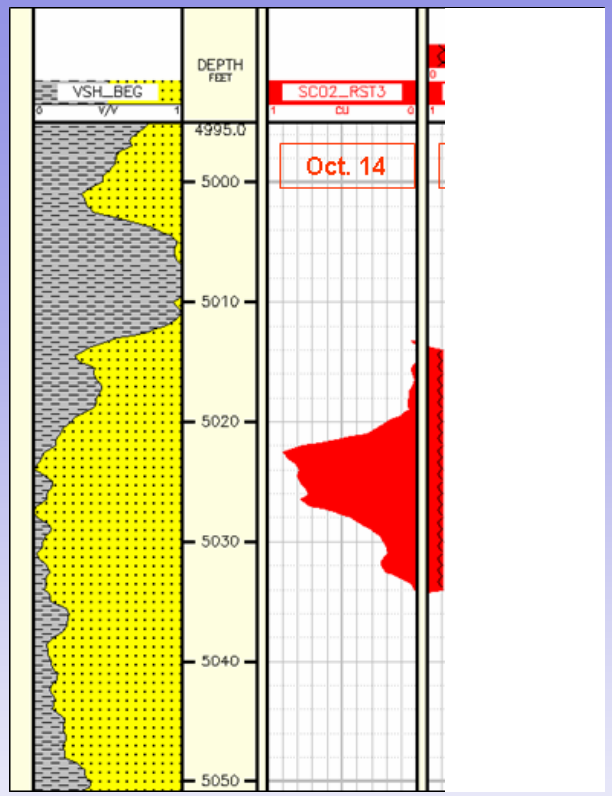


Data from Sandia Technologies

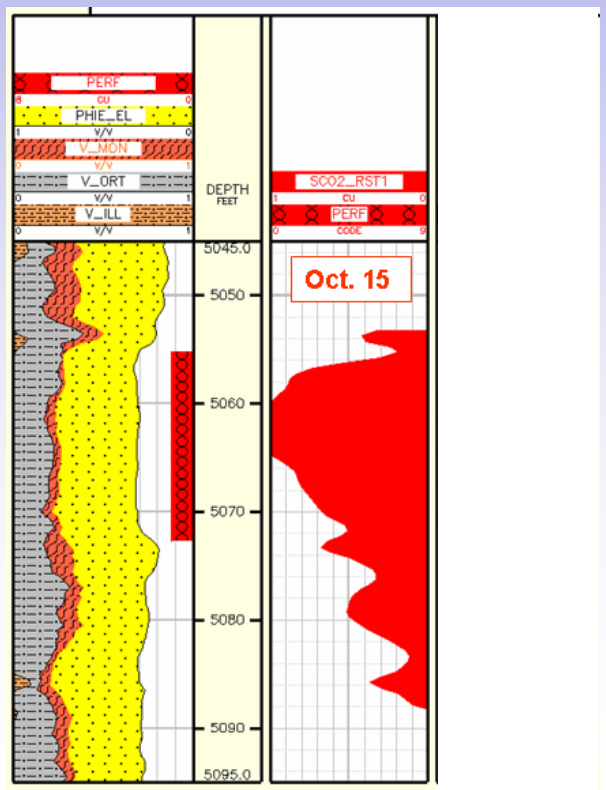
Sakurai et al., SPWLA, 2005

Change of CO_2 Saturation

The Observation Well



The Injection Well



* Saturation from PNC for end of Injection

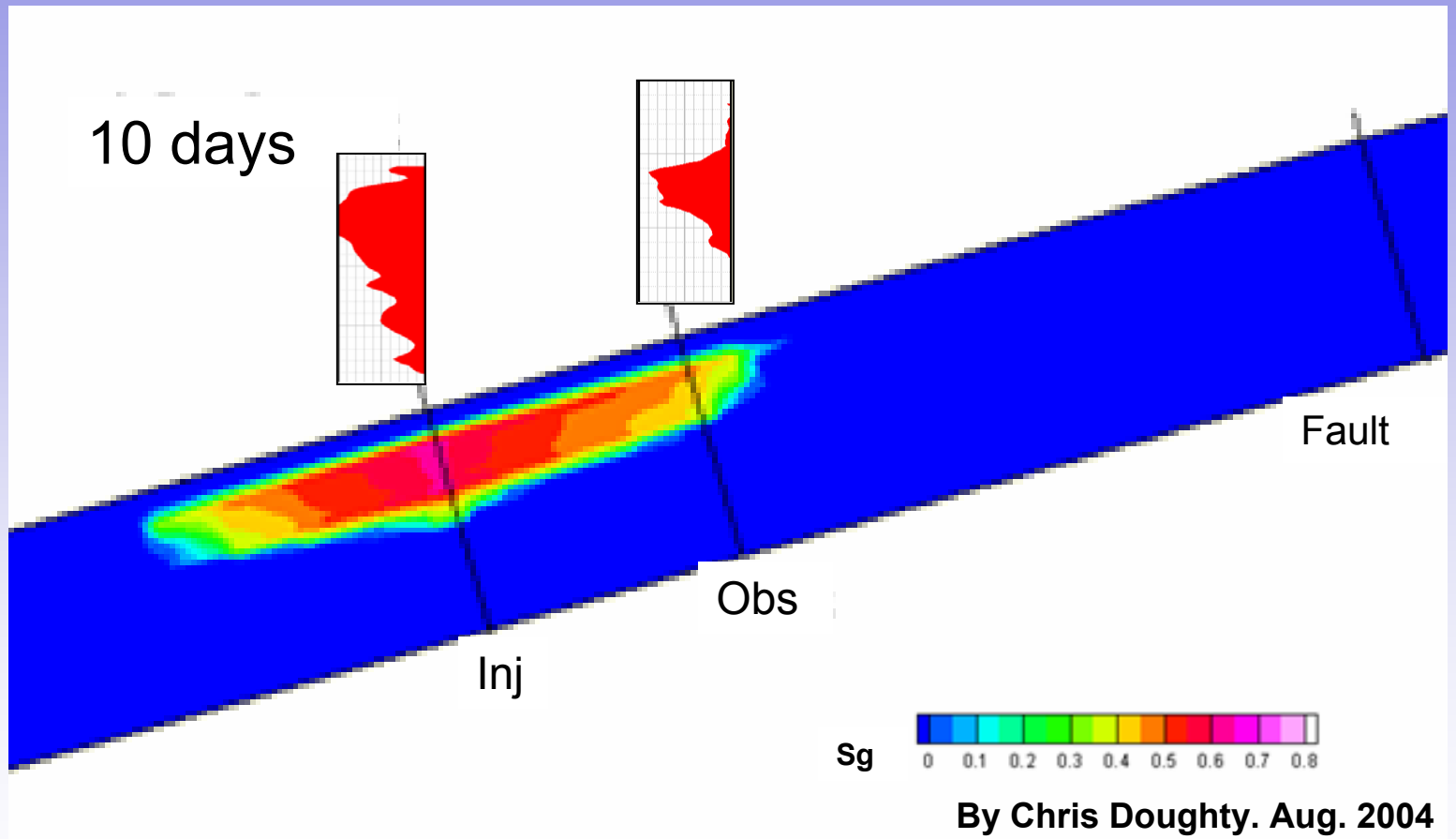
* After geophysical data acquisition

Modified from

Sakurai et al., SPWLA, 2005

Comparison of

CO_2 Saturation from PNC and Model Result



Comparison of

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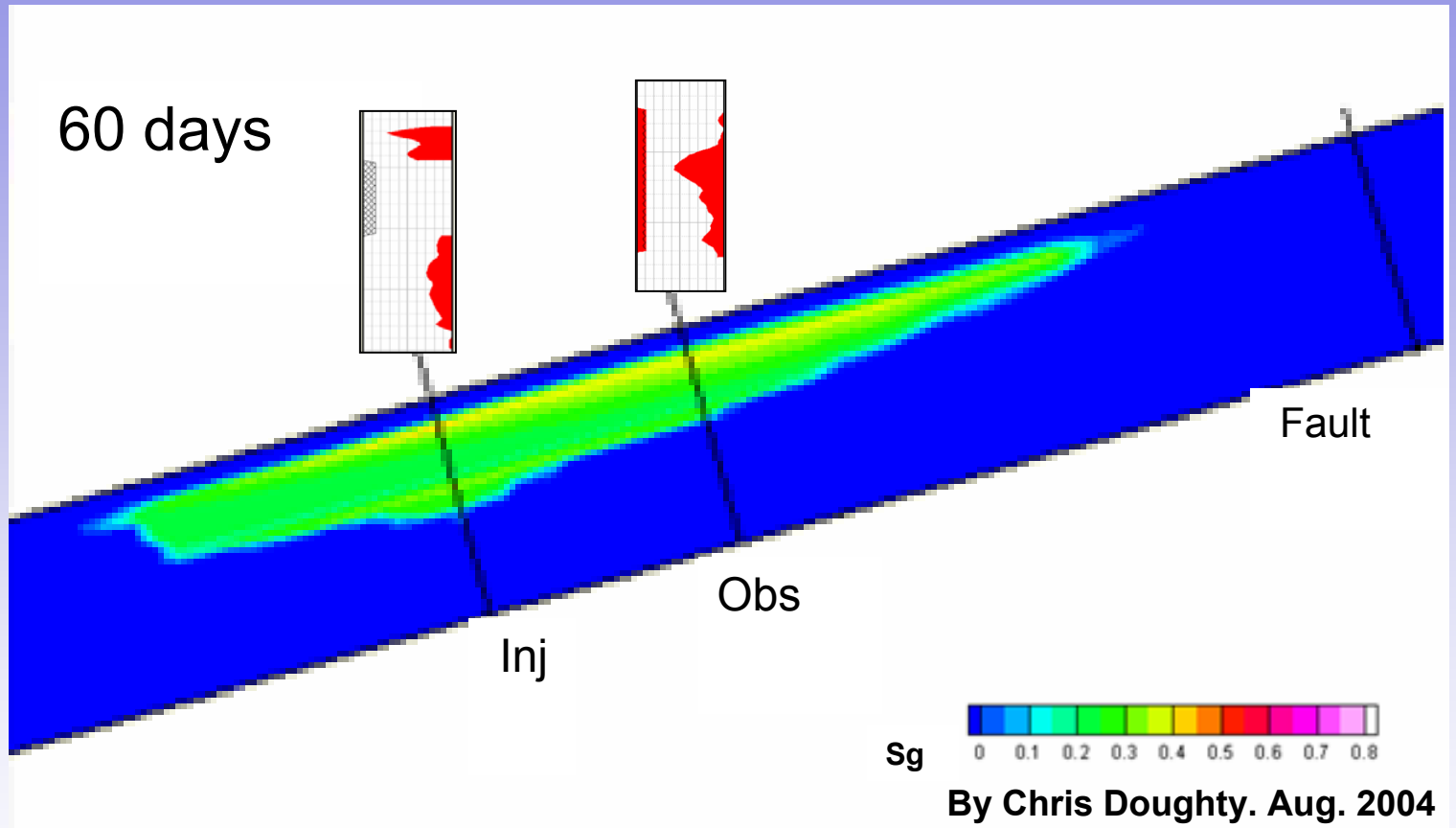
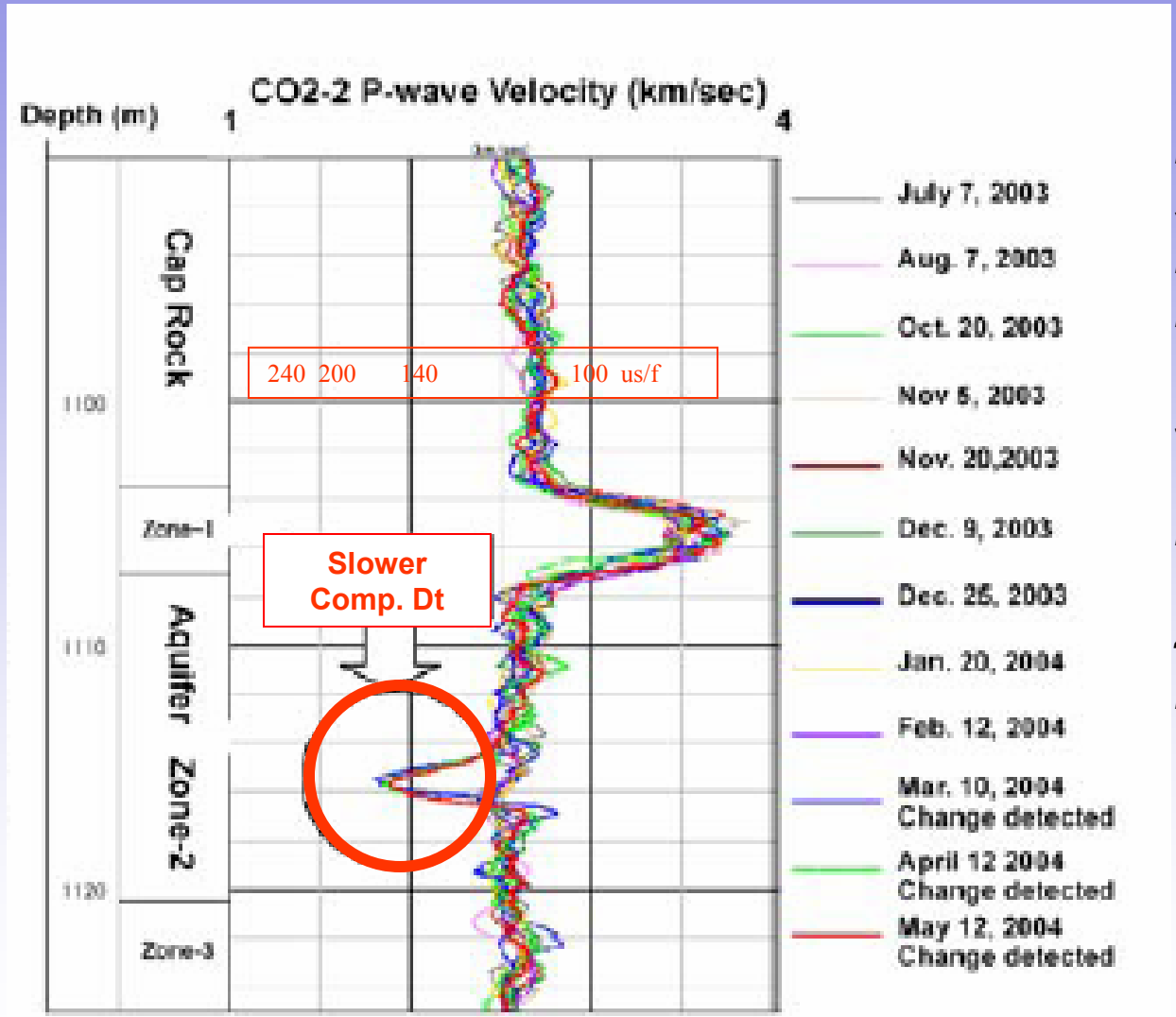


Sonic Transit Time

Example from Japan



Injected into sandstone of Haizume formation (L. Pleistocene).

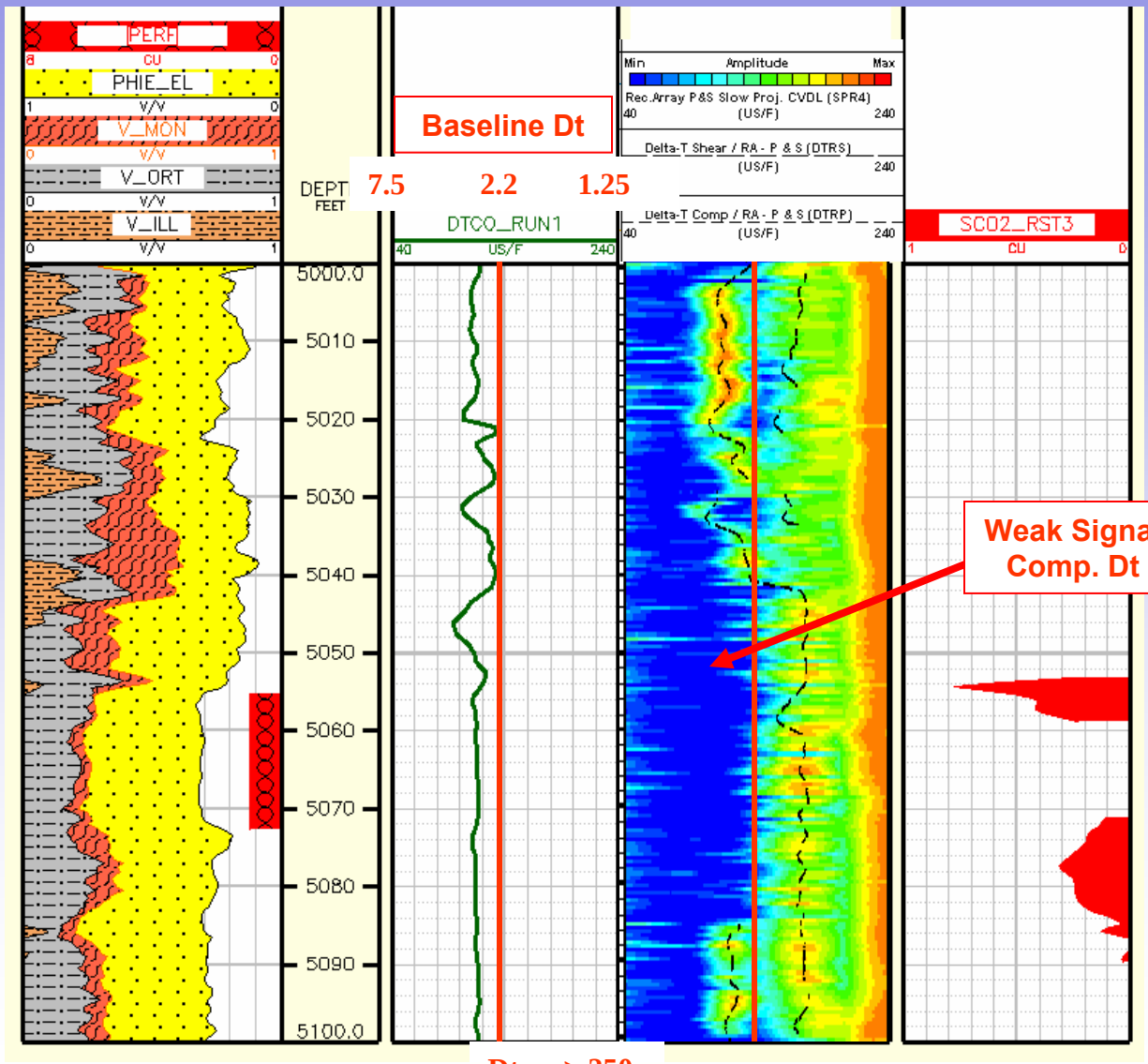
Slow Velocity due to CO_2, at March 2004, (8 months later).

4,000 ton of CO_2 was injected.

Kurika and others, 2004

Sonic Transit Time

Pre- & Post-Injection



Dtsm > 250

Slow Velocity due to CO_2, but not qualitatively

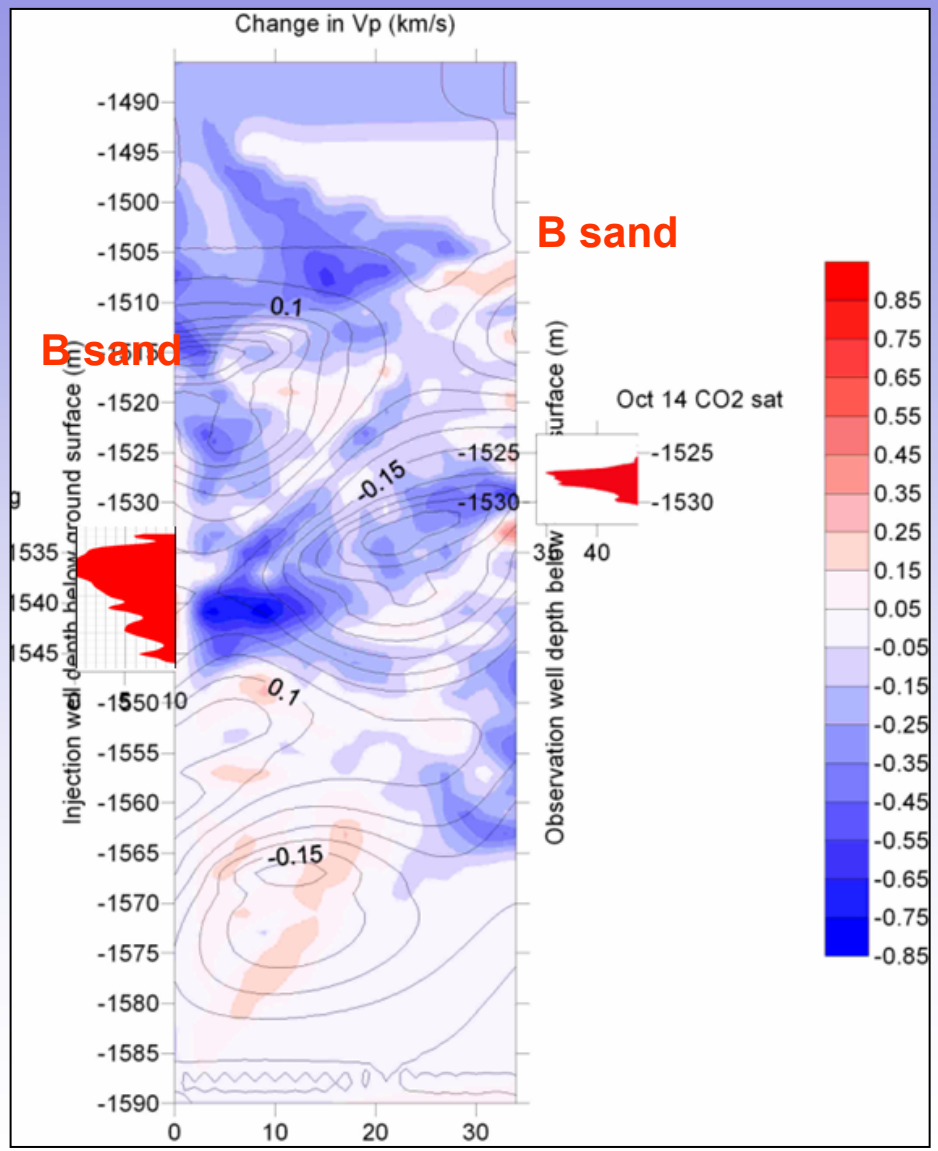
Processing of Casedhole DSI is on going at SDR

Vc 2800 – 1600 m/s
~ 40 % slower

CO_2 60%
Density 2.07 – 1.99 g/cc
ACIM 5800 - 3200

Change of Compressional Velocity

Pre- & Post-Injection



Work by J. Peterson & M. Hoversten (LBNL)

Slower Velocity was observed between 2 wells

Need to process post-injection Sonic log

Simulation Model

Electromagnetic Interference (EMI)

Study underway by Schlumberger's offices

SDR, Pittsburgh, & Bakersfield

Use computed results

Φ, K

CO_2 saturation

Estimate Saturation Changes in Model Layers

Compare with EMI data

CONCLUSIONS

* Integrated Evaluation is a Key for MMV

- **Addition of new core and wireline made an improvement on our Reservoir Description & update of input for model**

- **Based on core description, we changed perforation Intervals**

- **PNC worked well for CO_2 Saturation Estimate**

- **PNC - No sigma change over B sandstone**

- **Comparison is underway between CO_2 saturation from PNC and change of CO_2 distribution predicted by the simulation model**

- **CO_2 saturation from PNC, Velocity and density from wireline logs help Interpretation of Geophysics data**

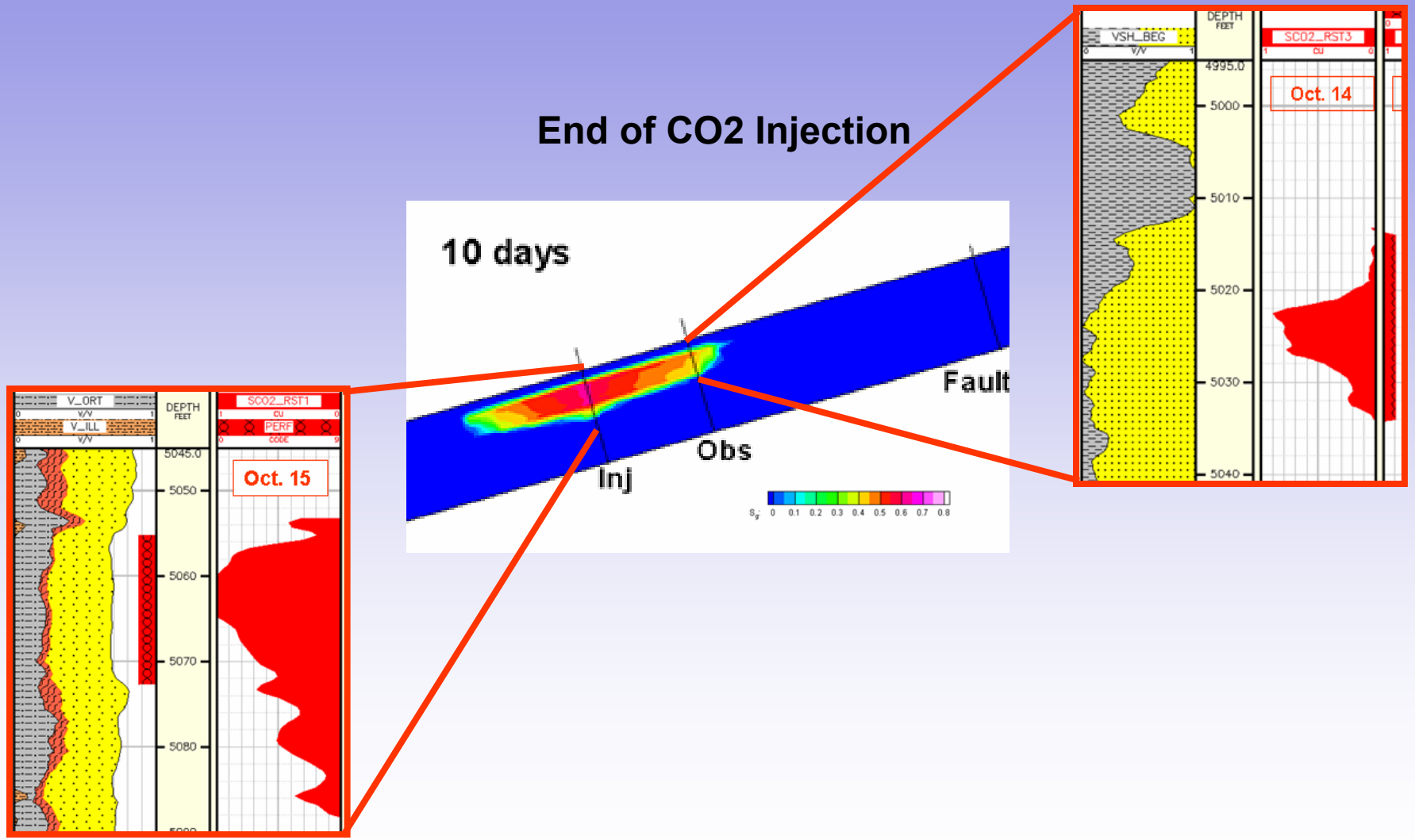
- **Additional PNC and Sonic logs**

Thank You
Photo by Spud Miller

Comparison of

Model Result and CO_2 Saturation from PNC

End of CO2 Injection



- MM&V is defined as the capability to:

- Measure the amount of CO_2 stored at a specific sequestration site,
- Monitor the site for leaks or other deterioration of storage integrity over time,
- Verify that the CO_2 is stored and unharmful to the host ecosystem

www.netl.doe.gov