KMS Technologies – KJT Enterprises Inc.

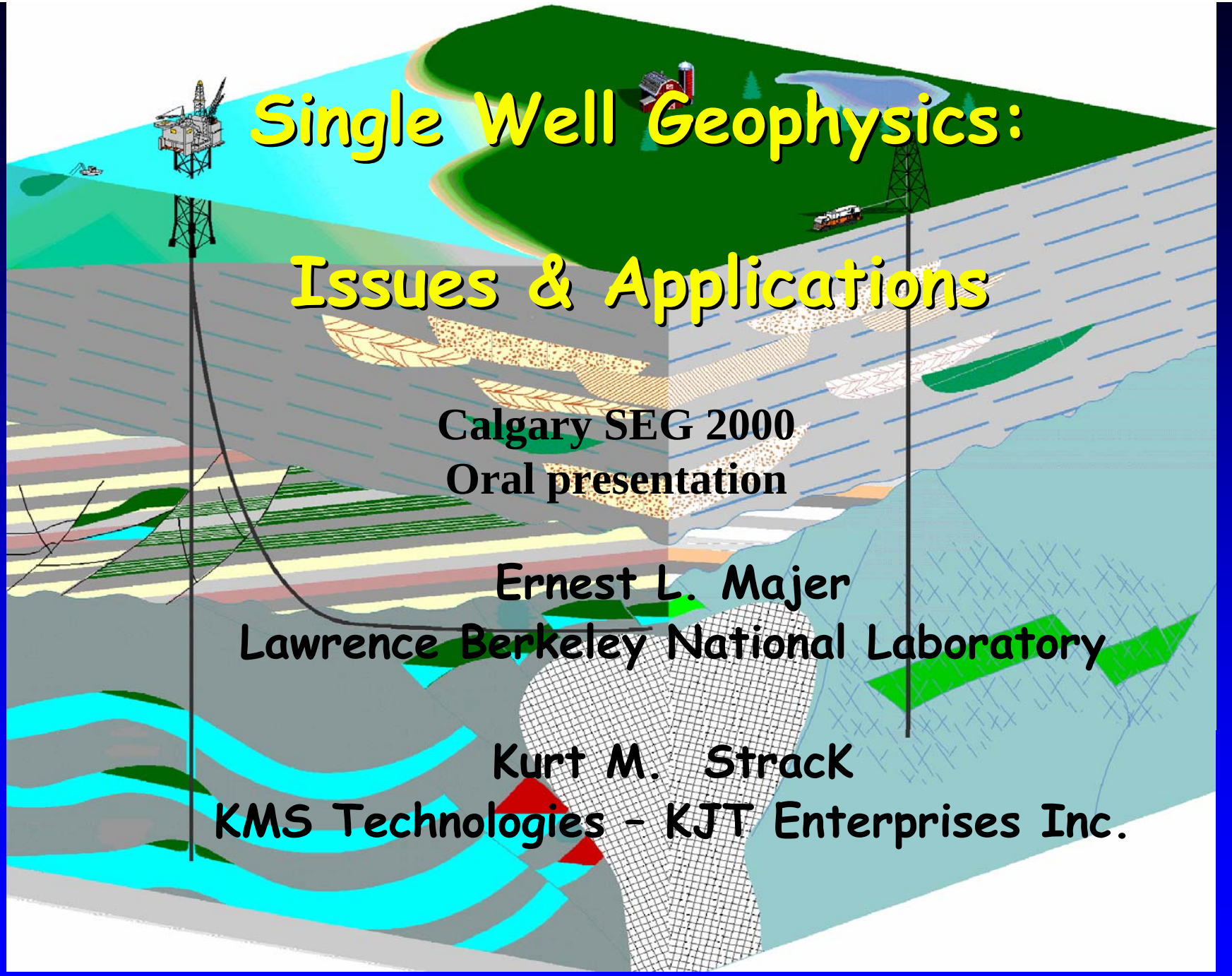
Presentation

Majer, E. L. & Strack, K. – M.

2000

Single Well Geophysics: Issues & Applications

Society of Exploration Geophysicists, Annual Meeting, Calgary, Invited Paper in workshop “Recent Advances and Road Ahead”



Single Well Geophysics:

Issues & Applications

Calgary SEG 2000
Oral presentation

Ernest L. Majer
Lawrence Berkeley National Laboratory

Kurt M. StracK
KMS Technologies – KJT Enterprises Inc.

Outline

- Need for Single Well
- Single Well Seismic
- Other methods:
  - Electromagnetics
  - Gravity
  - Synergies
- Future tasks

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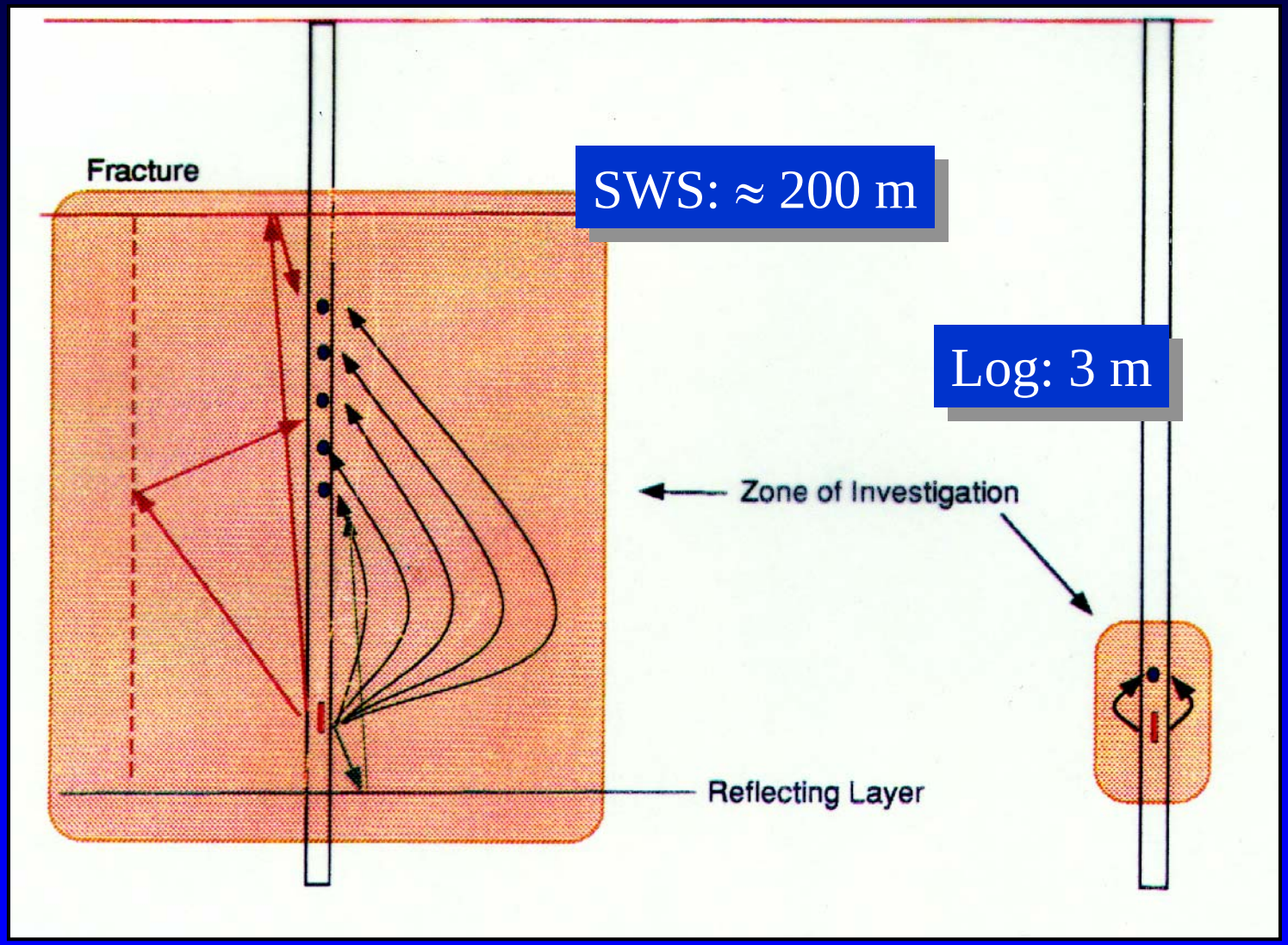
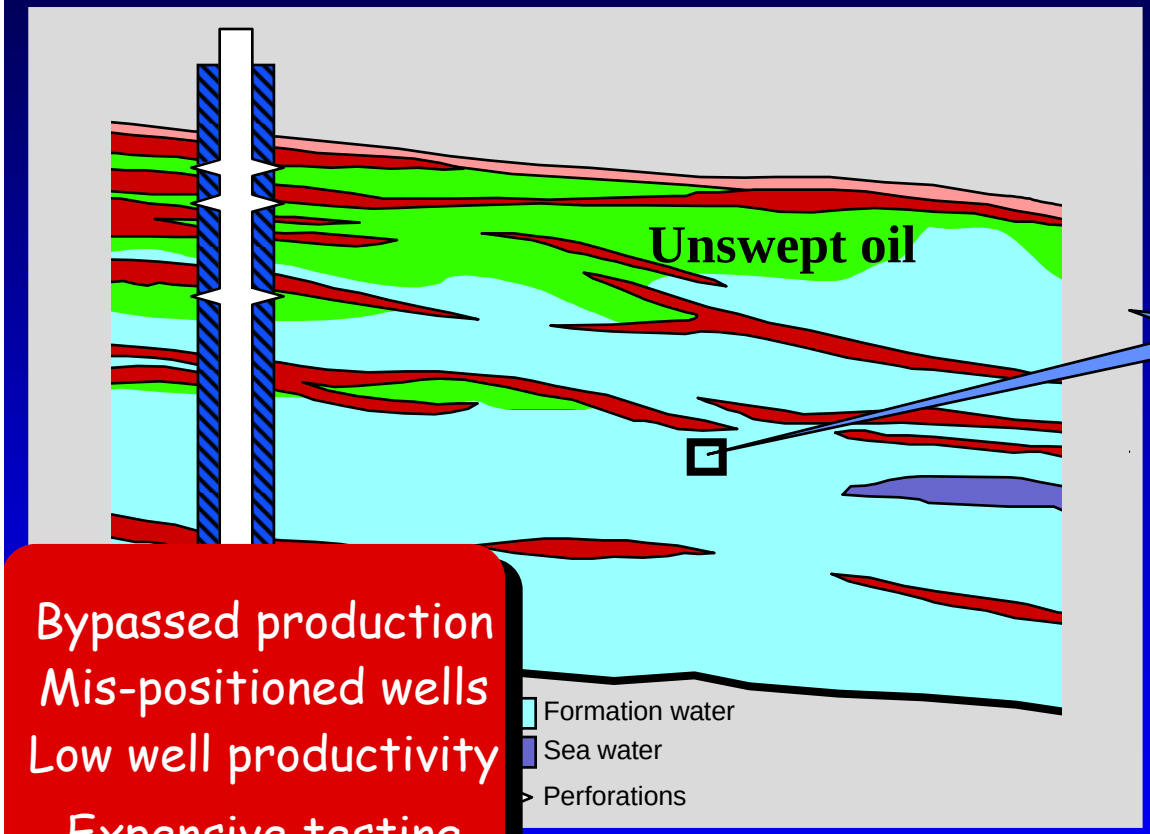
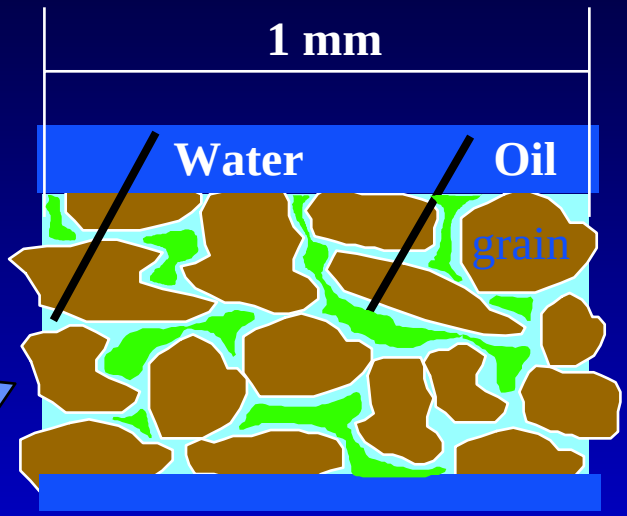
Resolution extension



DeepLook

Scope of the Challenge





Oil is trapped by surface tension & structure.

Bypassed production
Mis-positioned wells
Low well productivity
Expensive testing
Reserves uncertainty
Aquifer drive ??

<35%

70%+ recovery

Optimal well targeting

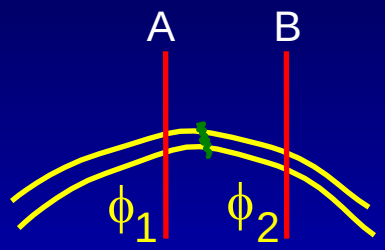
Right facilities

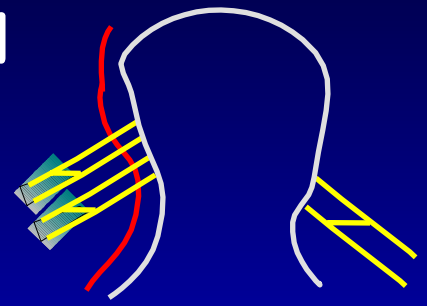
Minimum water production

70%

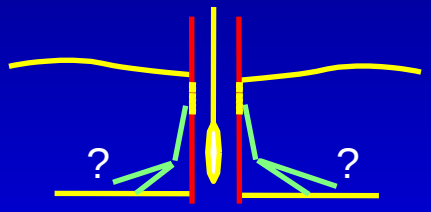
Class of problems

- Find pockets of hydrocarbons / structural

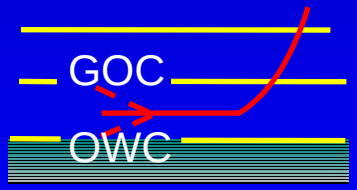


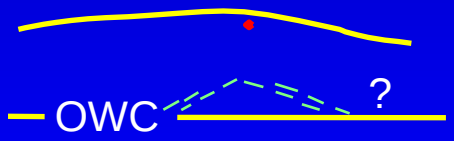


- Monitor production

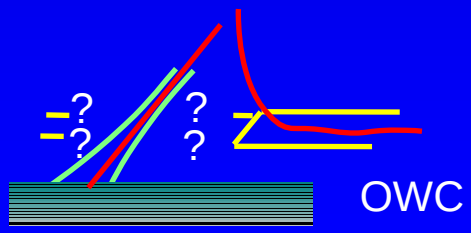


- Control / steer well path





- Control safety / environmental aspects



Outline

- Need for Single Well
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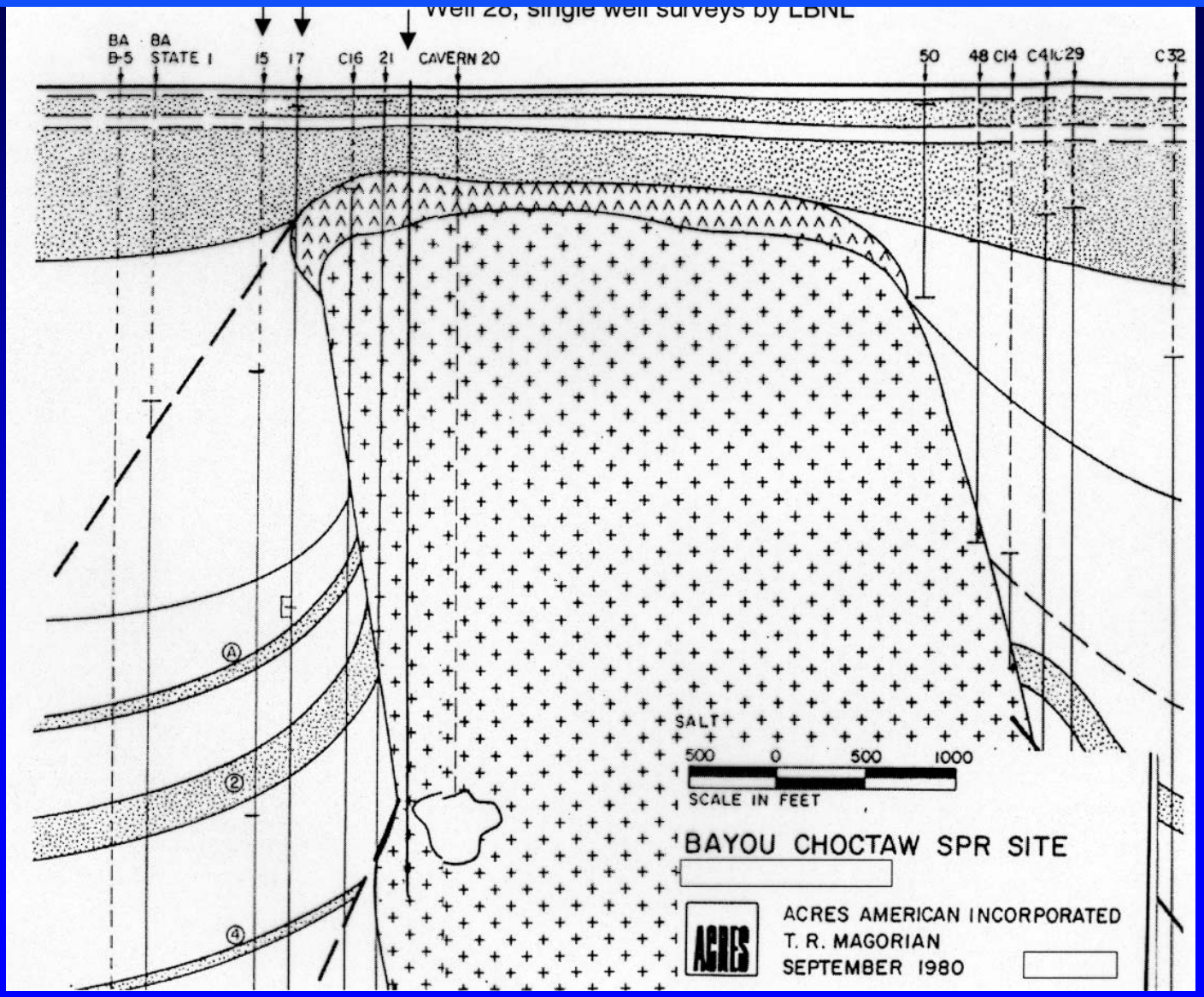
Single-Well Seismic Imaging: issues

- Source of Illumination
  - Bandwidth versus depth (I)
  - Tube waves
  - Multi-component
- Data Acquisition
  - Aperture
  - Directional receivers
  - Dynamic Range,24 bit versus 16 bit
  - Ease of deployment
  - Real-time
- Processing & Interpretation
  - True 3-D migration
  - Forward/Inverse Problems
- Verification & Ground Truth
  - Applications to real problems
  - Industrial cooperation

Associated Single Well Seismic activities

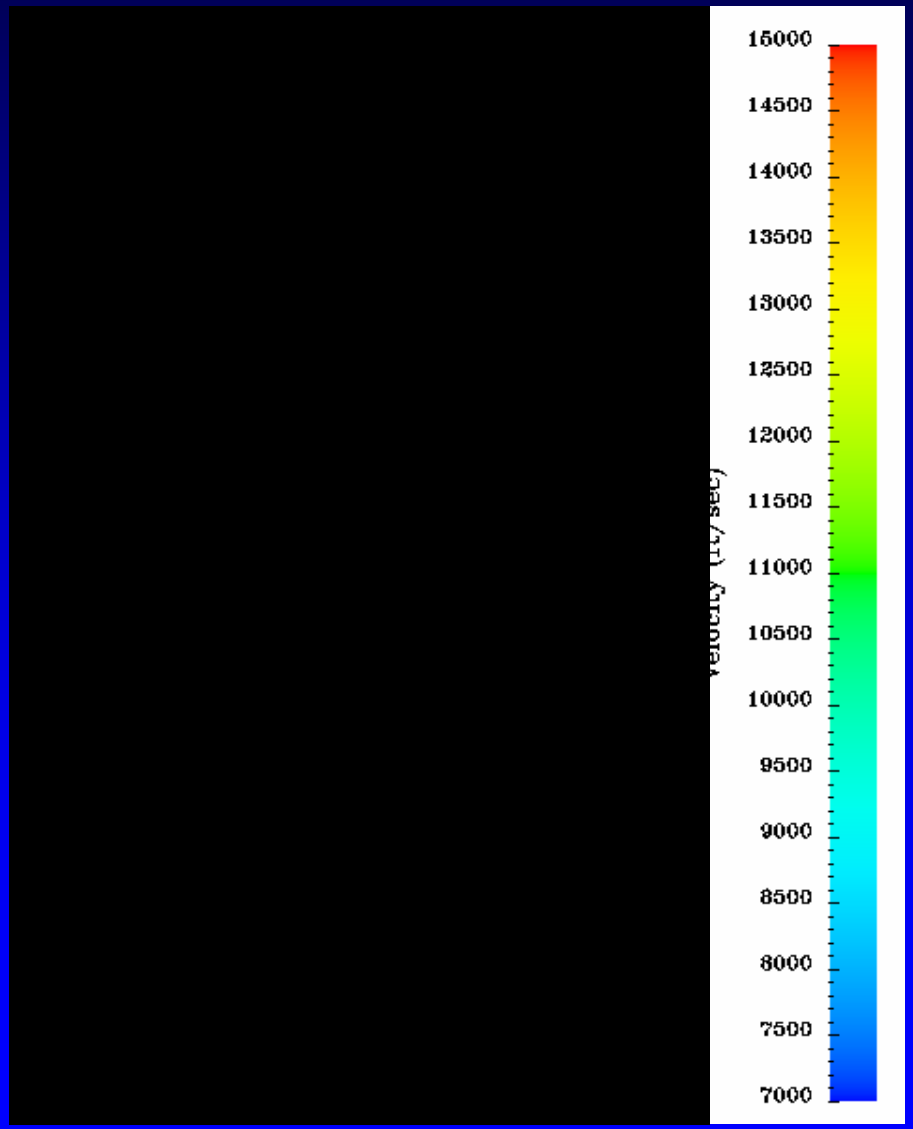
- **Field testing of sources & receivers**
  - Texaco air gun
  - Conoco orbital
  - Exxon piezoelectric
  - Tomoseis piezoelectric
  - P/GSI axial vibrator
  - Conoco 5 level
  - Exxon/Oyo 5 level
  - Conoco hydrophone
- **Axial vibrator crosswell tests**
- **Data processing/evaluation**
  - Source/Receiver strength/signal-to-noise comparison
  - Processed (migrated) crosswell image of air gun data
  - Initial analysis of data for reflected energy
- **Field test of Oyo packer clamping systems with Oyo sources**
- **Leveraged with over $3 Million of associated work**

Bayou Choctau sketch



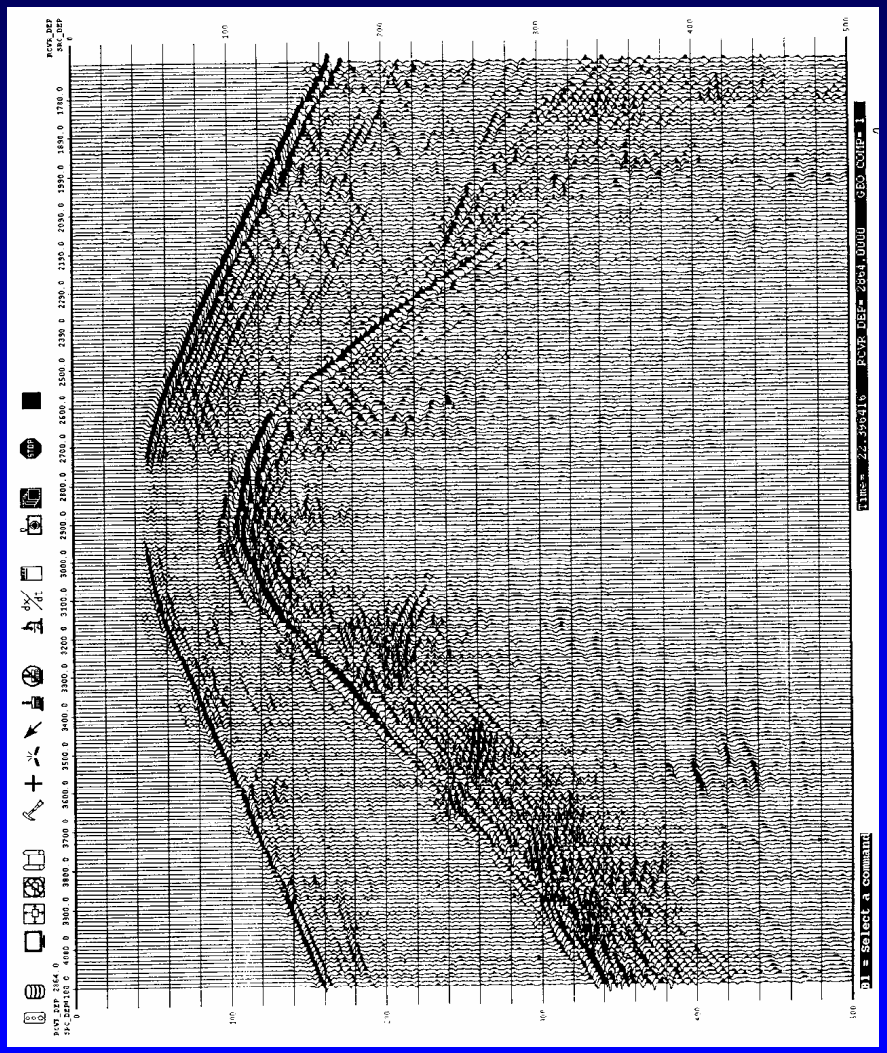
Final Model

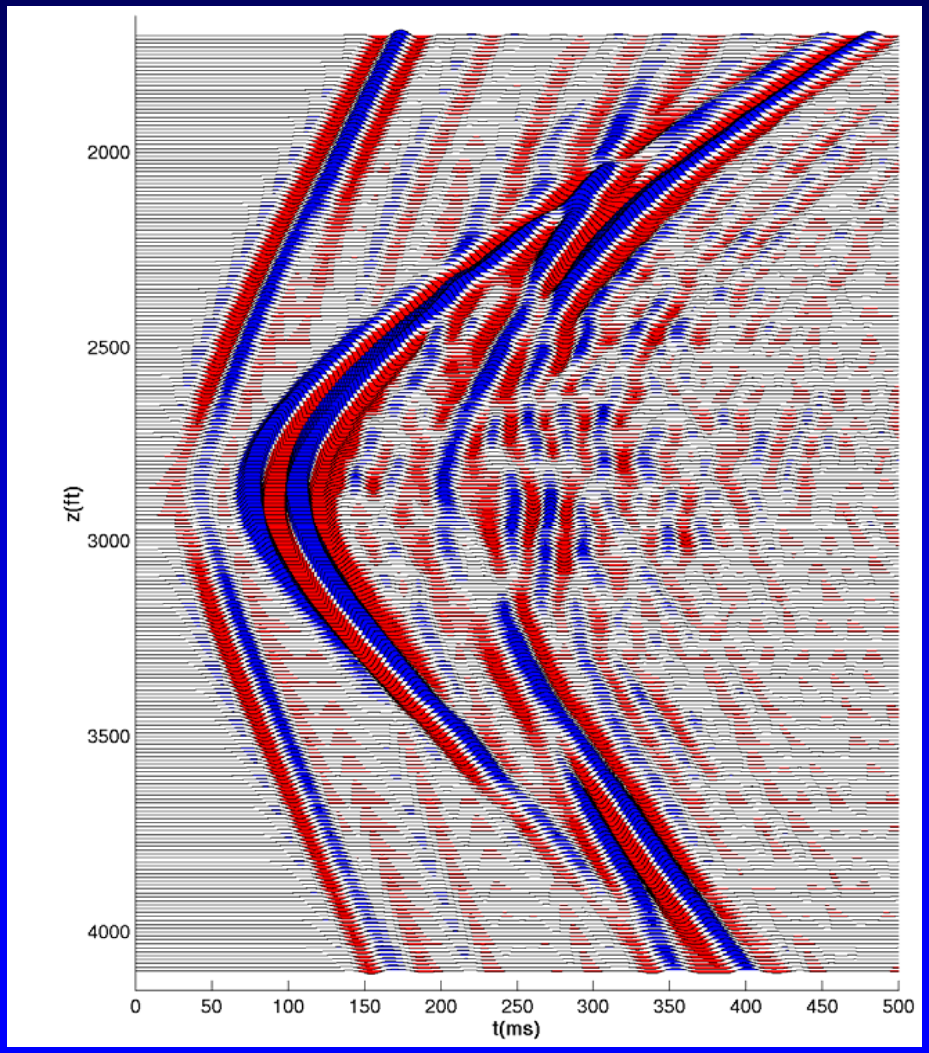
- Integrates previous models
- 90' rugosity on interface
- 20% perturbations to velocity & density



From D. Aldridge, SNL

Data versus model



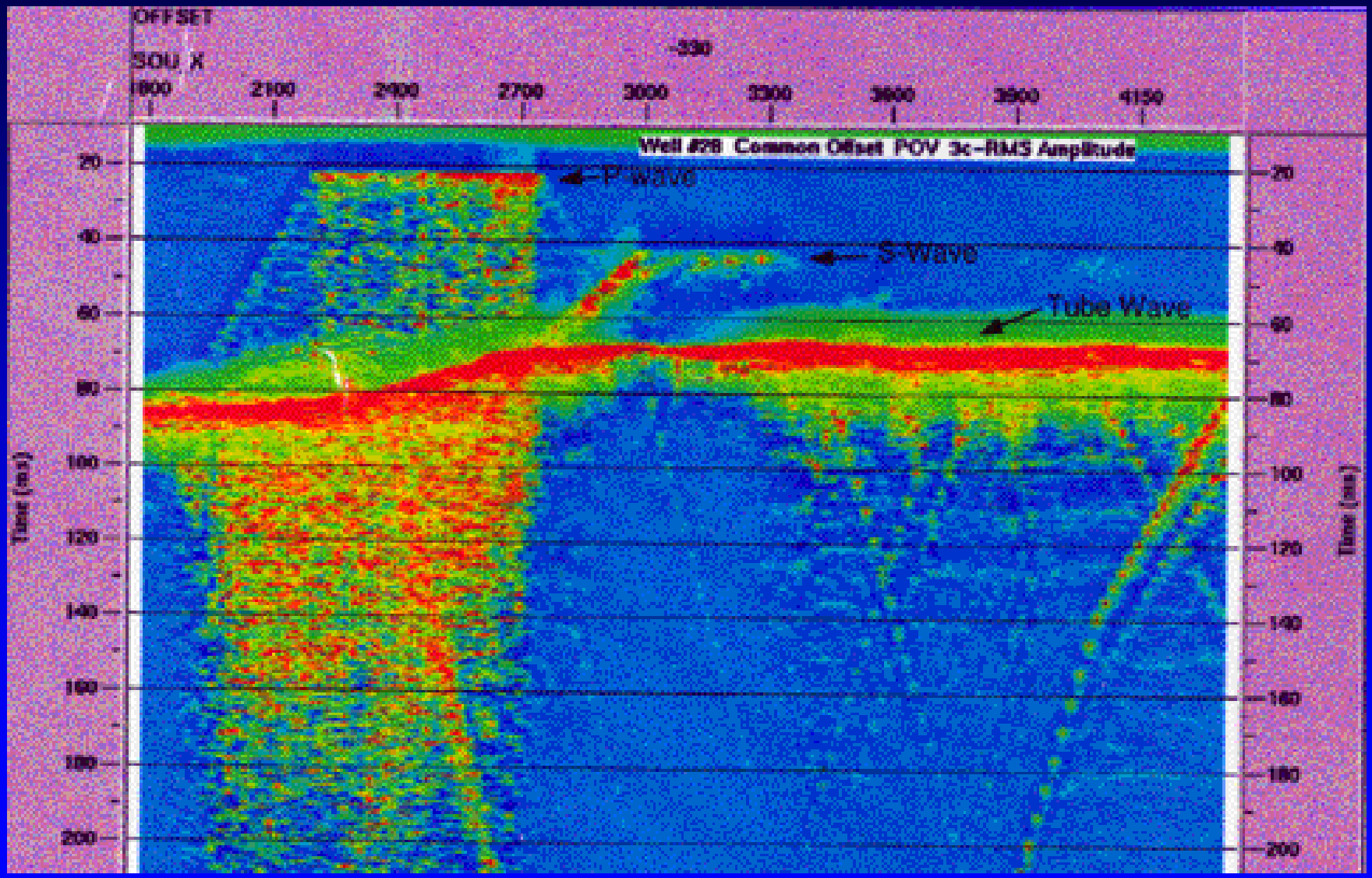


From D. Aldridge,

B.C. Tests 1999

Well	28					
	S	**R**	**Depth**	**Receiver Spacing**		**Offset (ft)**
1	Ac	3-c (5-L)	4030-3210	10	18 sweeps with T.W.S.	473
2	Ac	3-c	3200-1500	50	2 sweeps no T.W.S.	458
3	Ac	3-c	3300-1500	50	2 sweeps no T.W.S.	293
*4	Ac	3-c	4250-3400	10/20	8 sweeps	293
*5	Pov	3-c	4250-1800	10/20	25/4000+	290
6	Pov	3-c	3300	sweep test 700-3000 Hz	1,3,8,16+	290
*7	Pov	H.P.	4040-1300	10/20	25/4000+	401
8	Ac	H.P.	1800-1300	20	8 sweeps	397
9	Pov	H.P.	3400-2900	20	25/4000 -/+, +/-, +	253
Well	**17**					
10	Ac	3-c (12-L)	1500-4000	10	4 sweeps	640

Large scale SWS example



SWS results

- Multi-element system for testing of single-well seismic scenarios
- A comprehensive unique data set
- Full wave 3-D elastic code to model results
- Source terms, borehole effects & far field (geologic heterogeneity) can be included.
- Critical system interactions identified
  (Tube waves still a critical issue)
- NEXT: Integration with other methods

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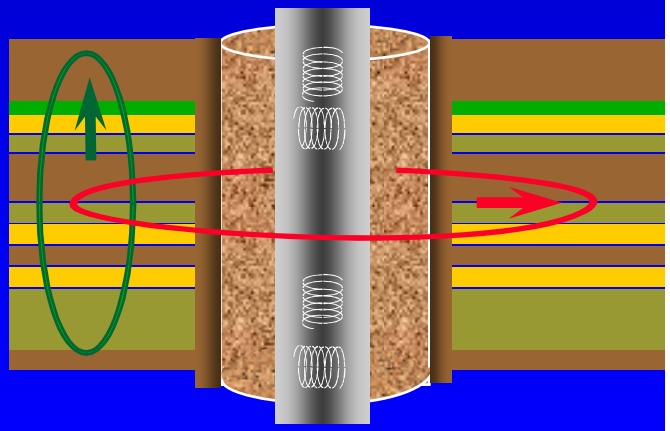
Single well EM tools

Very limited commercial success:

- Deep resistivity for many years (ULSEL - SLB)
- Deep induction in 80s (MPI)
- Specialty tools (EMI: MAIL & SCIL)

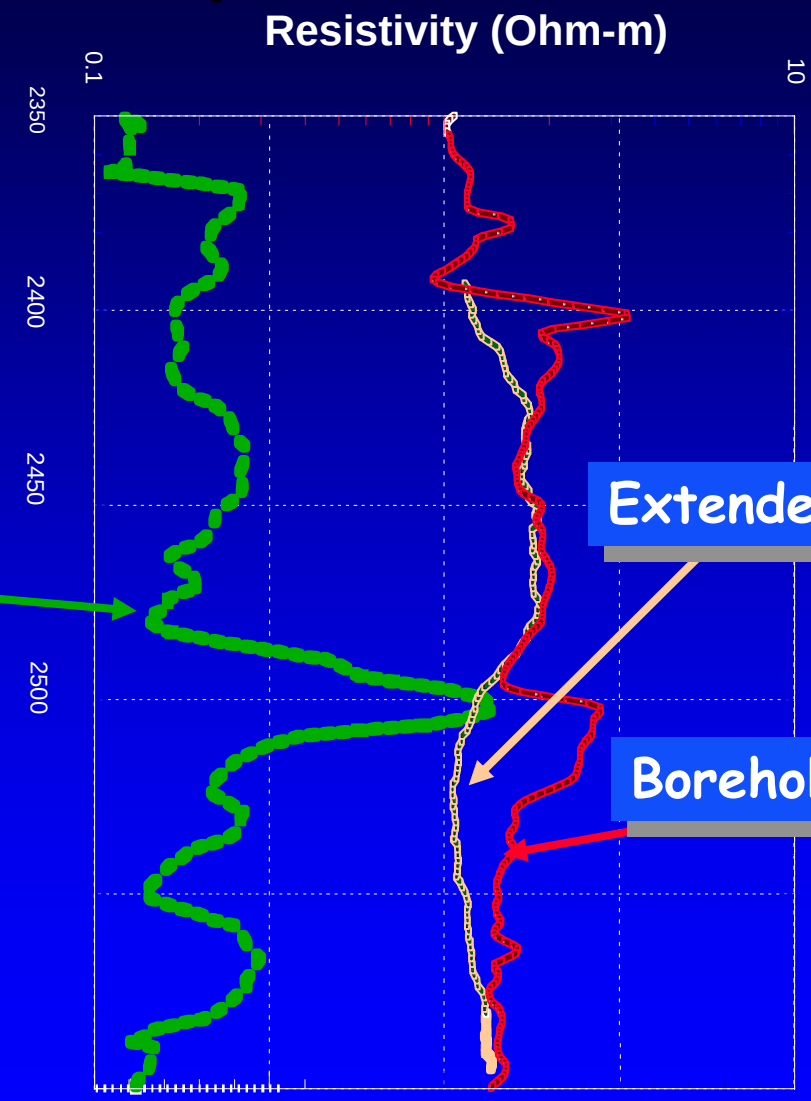
NEEDED

- 9 component integrated tool (deviated wells)



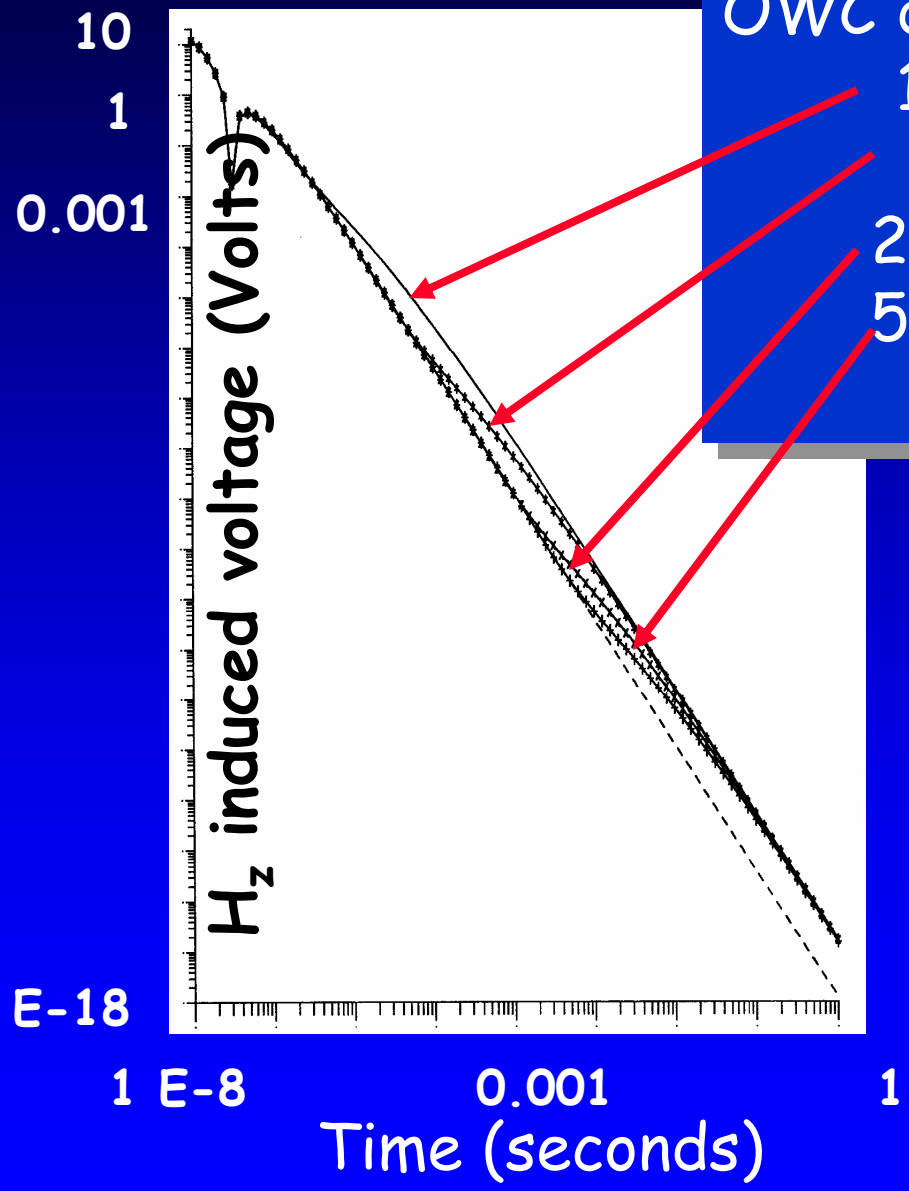
FD log example

SCIL tool



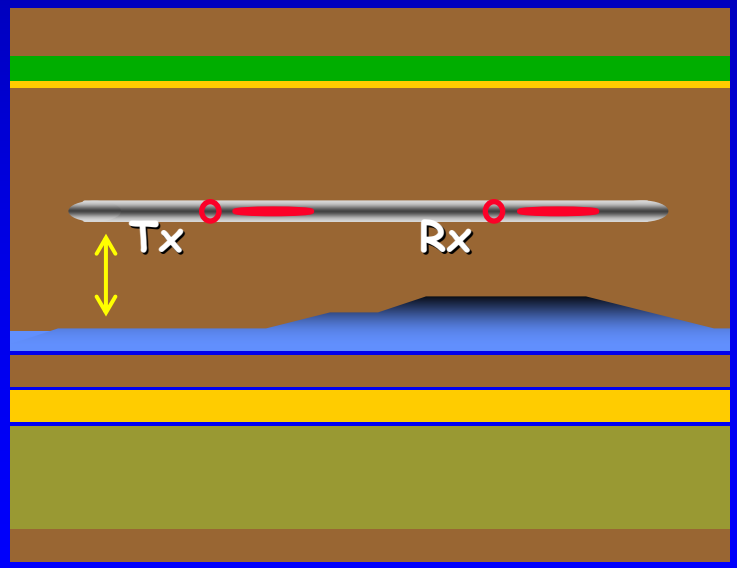
Courtesy of EMI Inc.

Time domain difficulties



OWC distance
1 m
5
25 m
50 m

Water coning in a horizontal well



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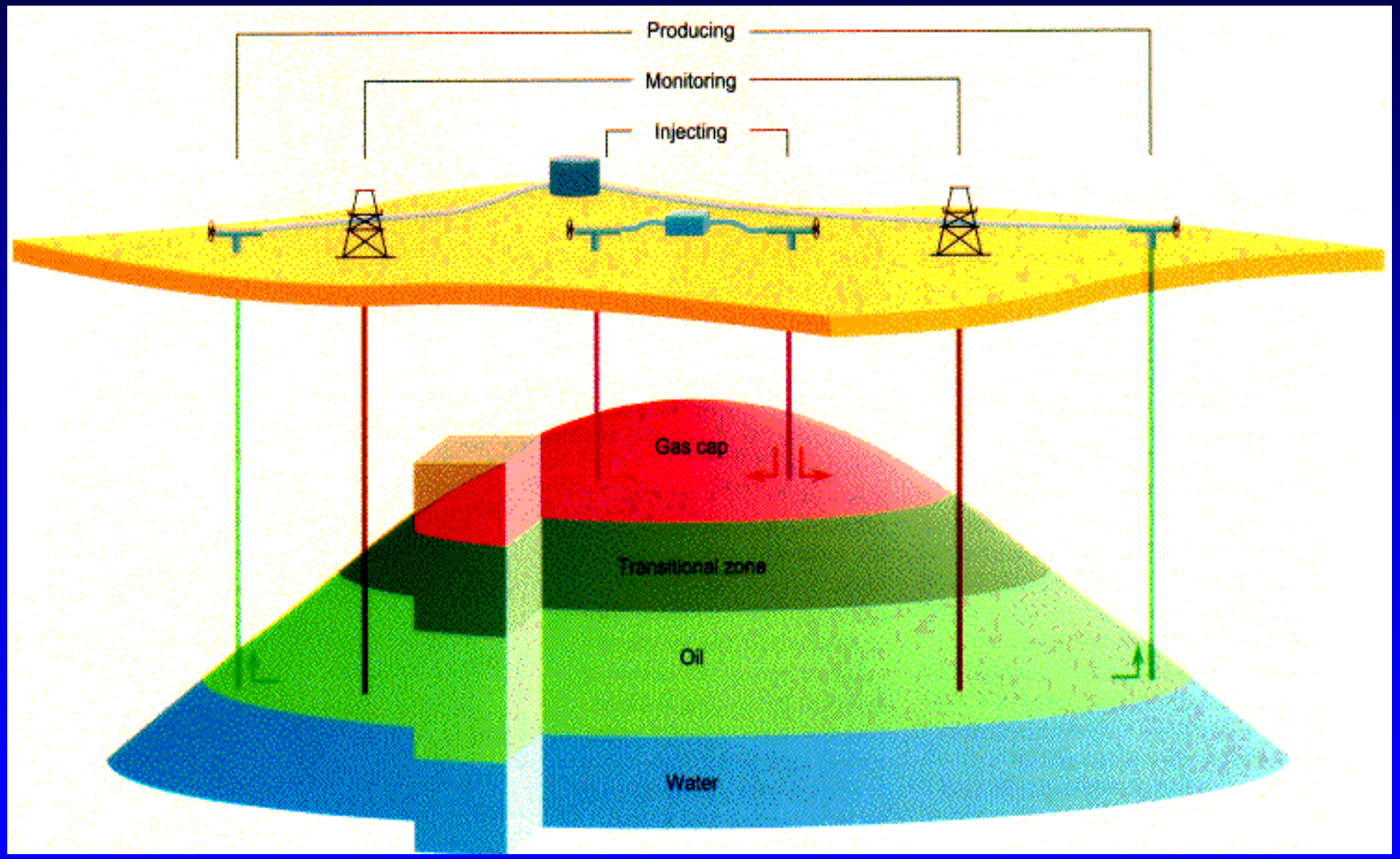
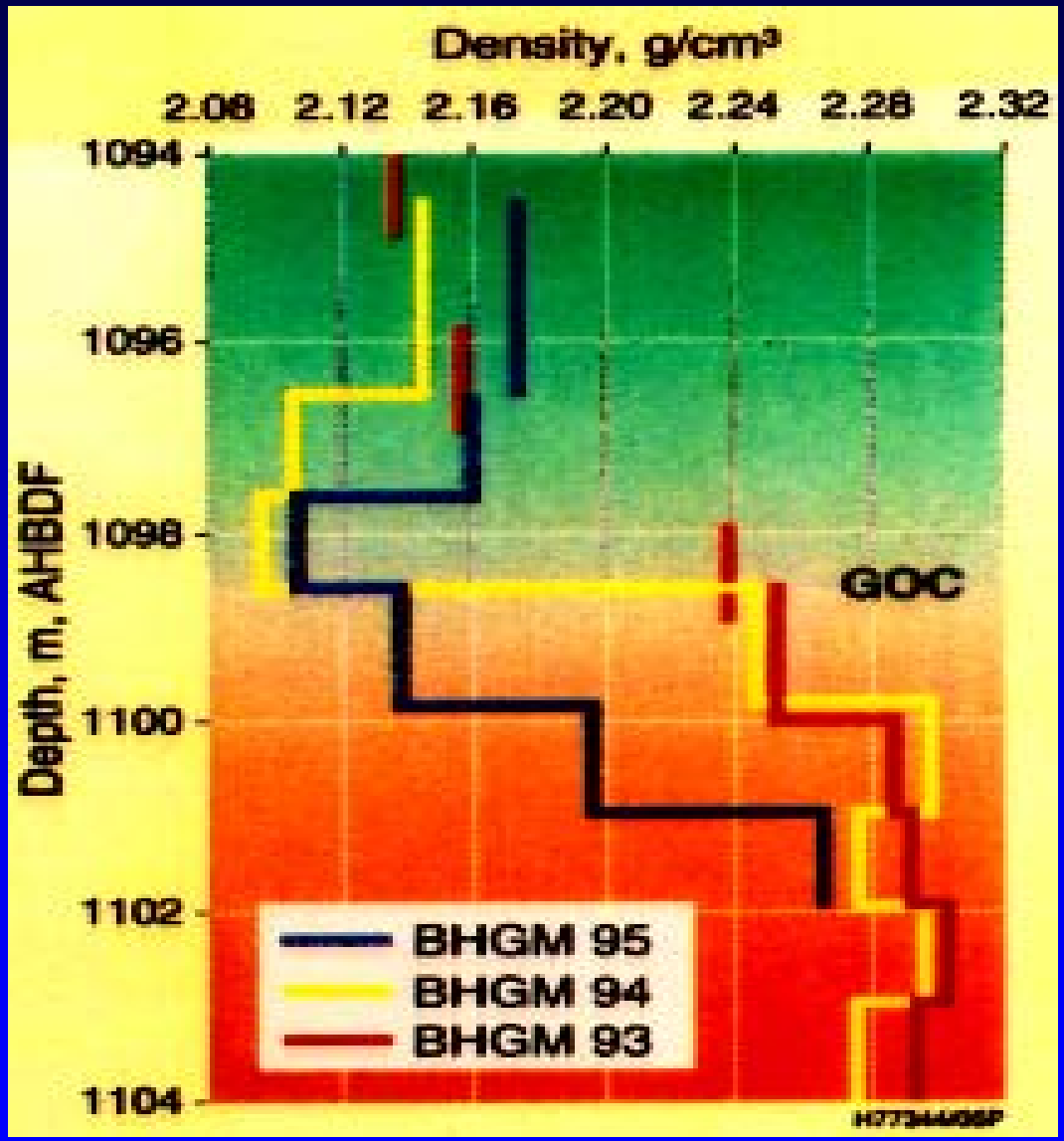
Traditional oil & gas production



BHGM densities for 3 years

Repeat BHGM across Rabbi field gas/oil contact in Gabon.

Porosity: 24%
Gas ρ : 0.082 g/cc
Oil ρ : 0.780 g/cc



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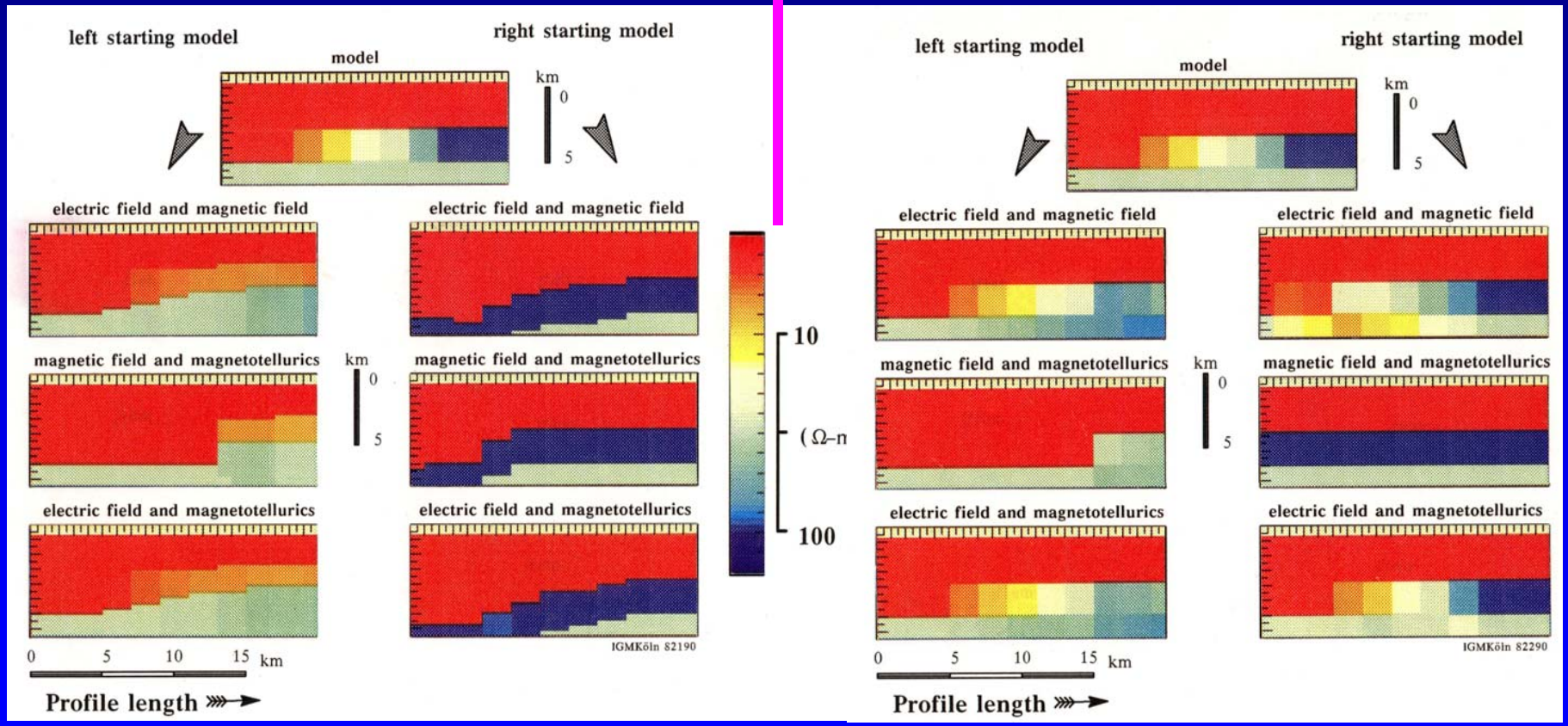
Example of Synergy

EM methods combined

EM constraint by seismic



KMS990009k

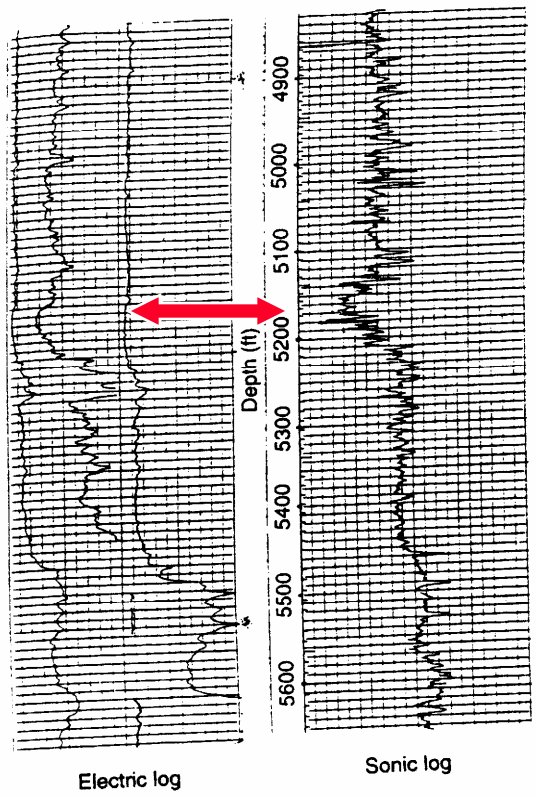
After Strack, 1992

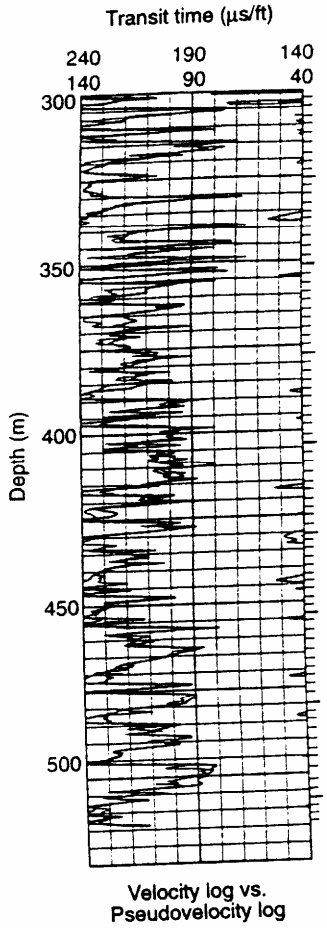
KS92

Seismic – EM correlation

- Logs often correlate
- Pseudo logs used
- Res. Logs used for AVO calibration

Feature correlation





2 logs

After Strack & Vozoff, 1996

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Single well methods status

- Seismic cross well — commercial
- Seismic single well — commercial trial
- EM cross well — commercial trial
- EM single well — FDEM: experimental; TDEM: research
- Borehole gravity — Big: commercial; Small: research

Outlook: Single well geophysics

- Seismic:
  - Tube wave modeled & properly acquired, not solved yet
  - Complex survey modeling
- Electromagnetics:
  - Limited commercialization FEM
  - Develop TEM & demonstrate
- Gravity: smaller sensor (360°, high temperature)

Goal:

- Integrate system seismic + other methods

Summary

- Single well seismic is being applied!
  - Some issue remain
- Benefits of other techniques limited
- Methods now need to be integrated with seismic system
- Primary challenges will be true joint acquisition, as well as inversion

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