



Cross Well Electromagnetics: Reservoir Surveillance and Monitoring Technology

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Ping Zhang received his PhD degree in geophysics from Uppsala University in 1989 and joined Schlumberger in 1999 where he currently serves as Principal Geophysicist.

He was an assistant researcher in University of Montreal, Canada from 1990 to 1994 and an area geophysicist for Inco Ltd, a mining company in Canada from 1995 to 1998. His research has focused on the application of electromagnetic (EM) technologies for geophysical exploration and characterization, with emphasis on developing numerical techniques that are used for interpretation of EM data.

Ping has worked on crosswell EM data quality control, processing, inversion and interpretation for petroleum applications. He is also actively involved in studies and development for reservoir monitoring and characterization. He is member of SPE and SEG.



Dr. Ping Zhang
Principal Geophysicist
Schlumberger



Agenda



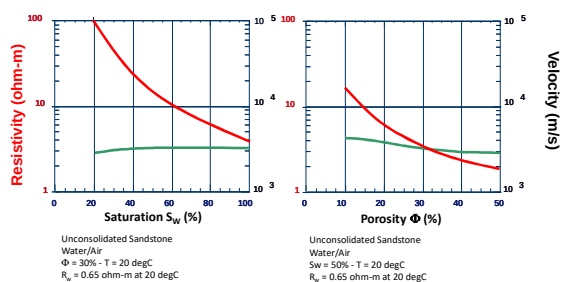
- Introduction
- Electromagnetic survey technology
- Cross-well EM
- Case history
- Conclusions



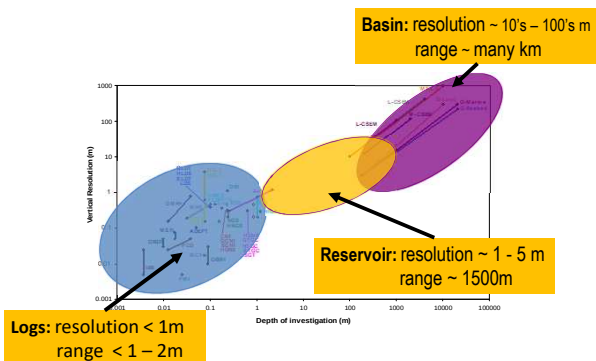
Why Using Electromagnetic Method ?

Hydrocarbons: highly resistive
Formation water: highly conductive

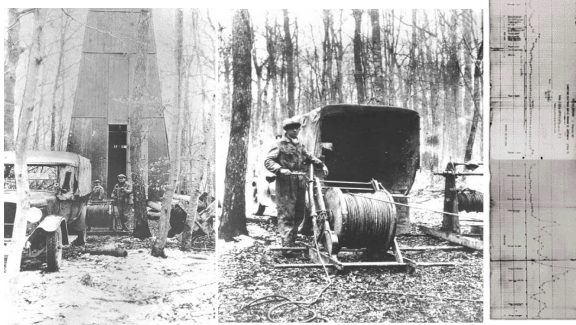
$$R_t = a \frac{R_w}{\Phi^m S_w^n}$$



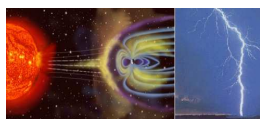
EM Survey Methods



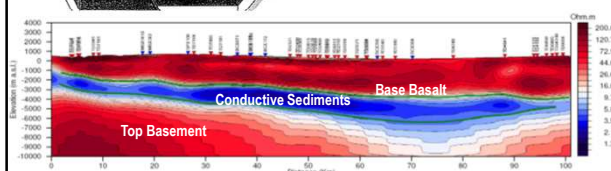
Pechelbronn, 5 September 1927



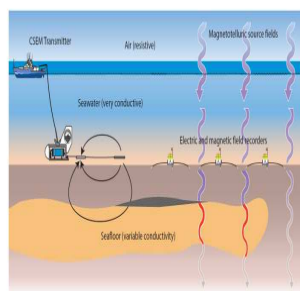
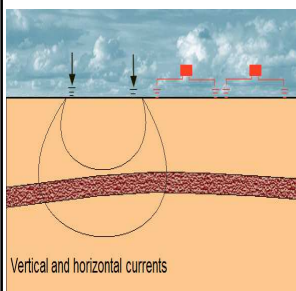
The Magnetotelluric (MT) Method



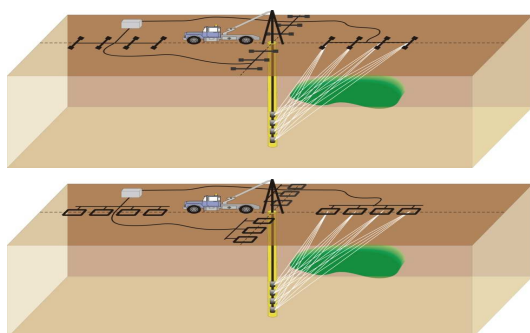
- Natural magnetospheric and ionospheric sources induce currents in the earth subsurface
- EM fields are recorded passively on the earth surface
- Post processing yields subsurface resistivity distribution
- Very shallow to very deep exploration



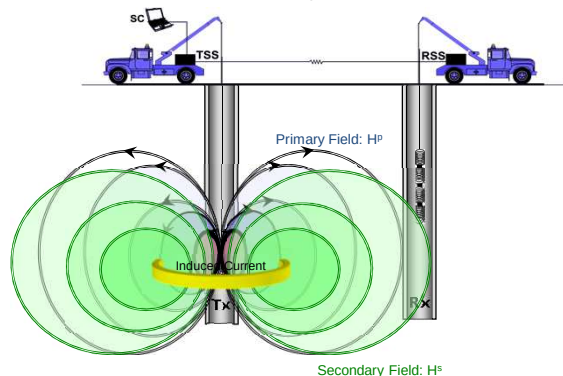
Control Source EM (CSEM)



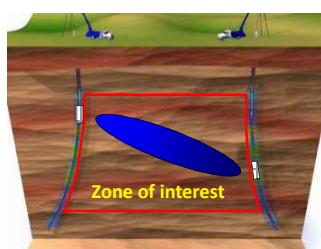
Surface to Borehole EM

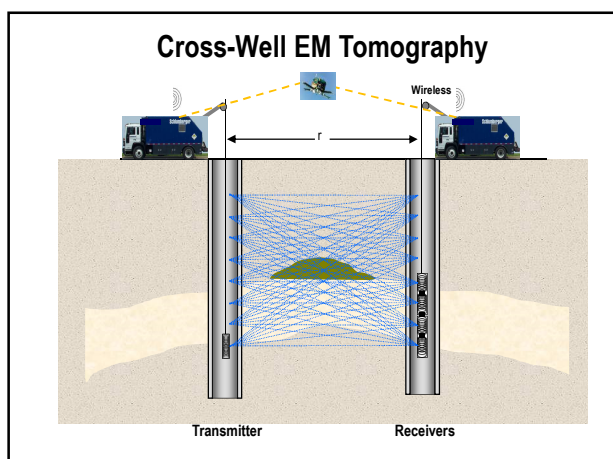


The Measurement Principle of Cross-Well EM



Inter-Well Region Interrogated By Tomography





Tool Specifications

Transmitter

OD: 3 3/8" (86mm)

Length: 9.88m

Receivers

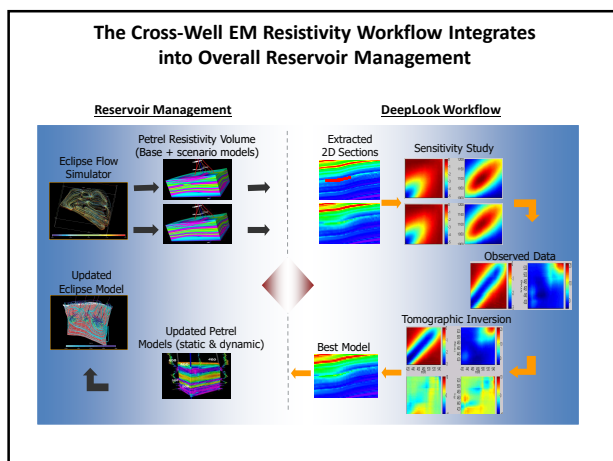
OD: 2" 1/8 (54mm)

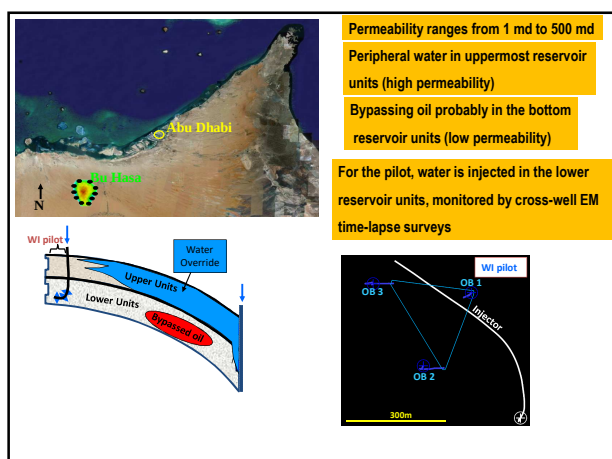
Length: 22.5m for 4 receivers

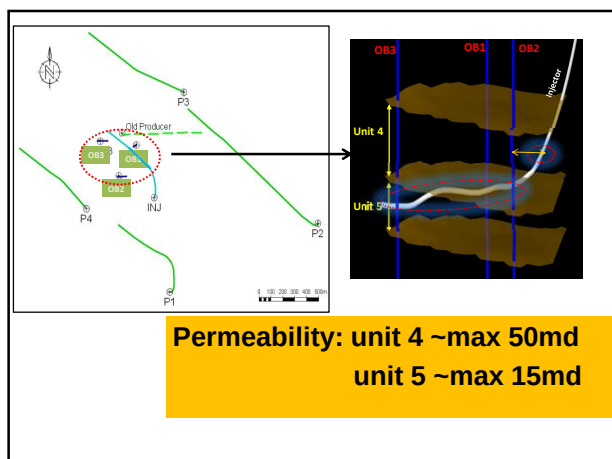
Optimized at frequencies from 10-1000 Hz

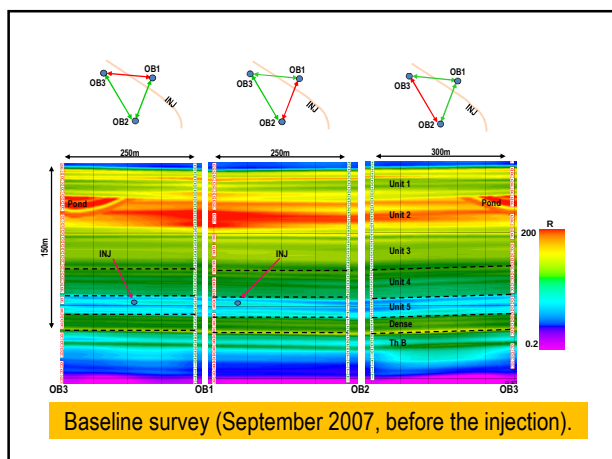
Well type and separation

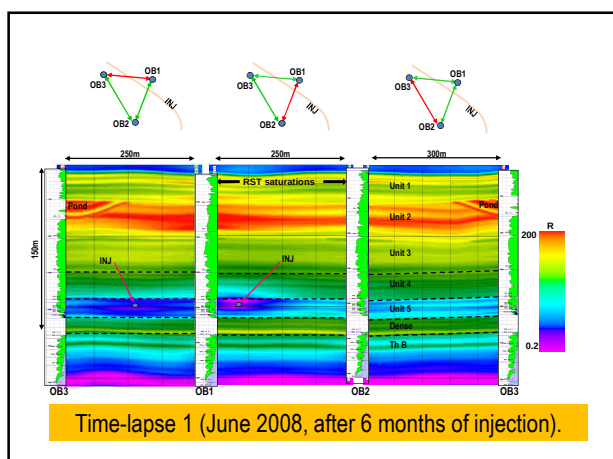
Transmitter Well	Receiver Well	Max Spacing
Open	Open	1500m
Fiberglass	Fiberglass	1500m
Open	Steel casing	700m
Steel casing	Steel casing	n/a

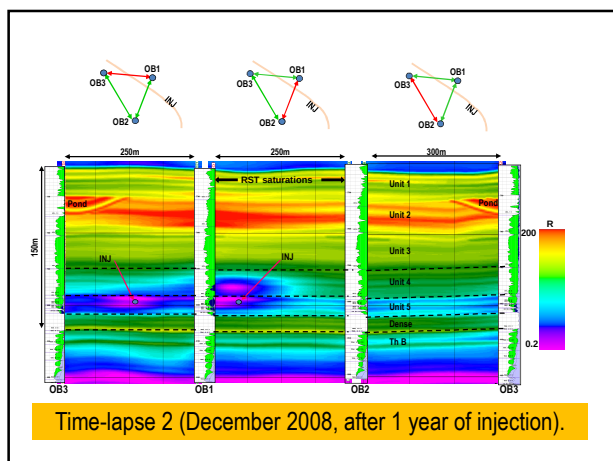


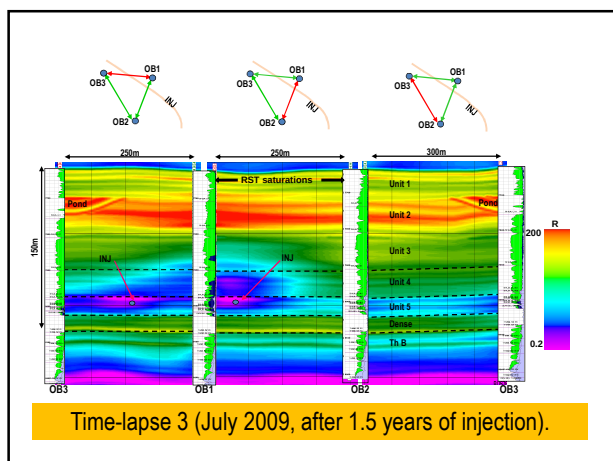


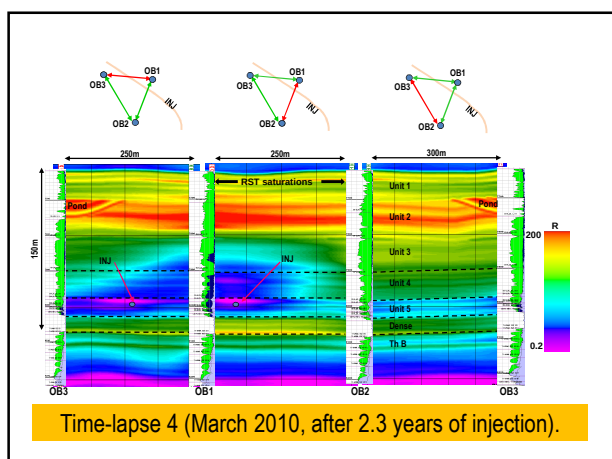


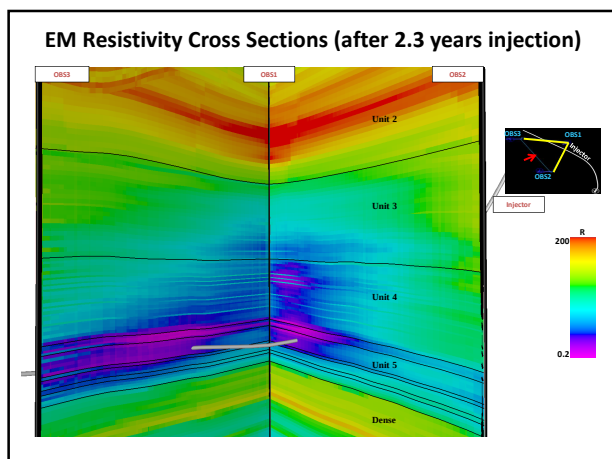


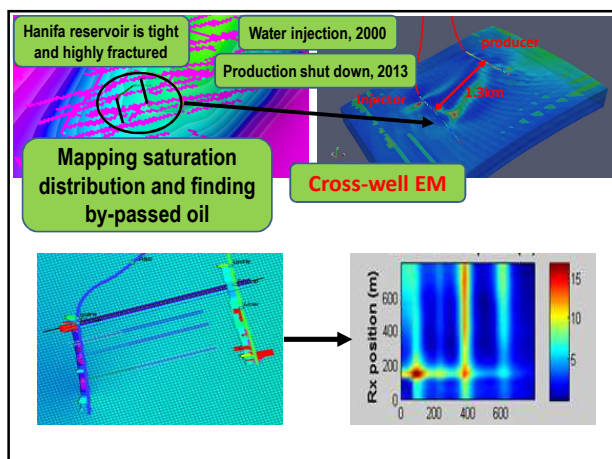


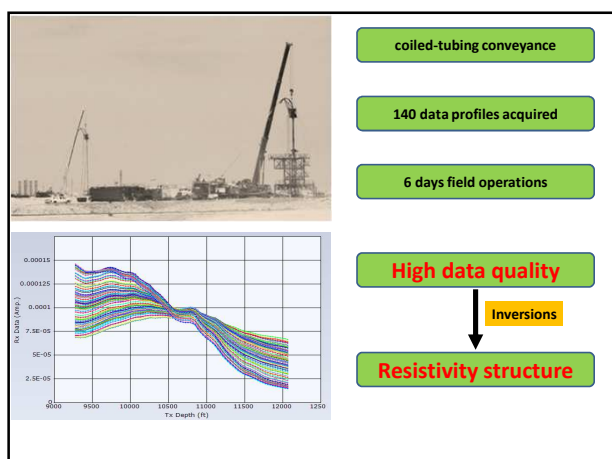


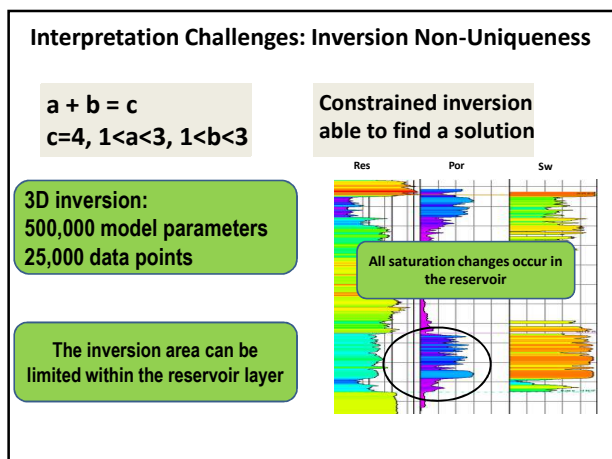


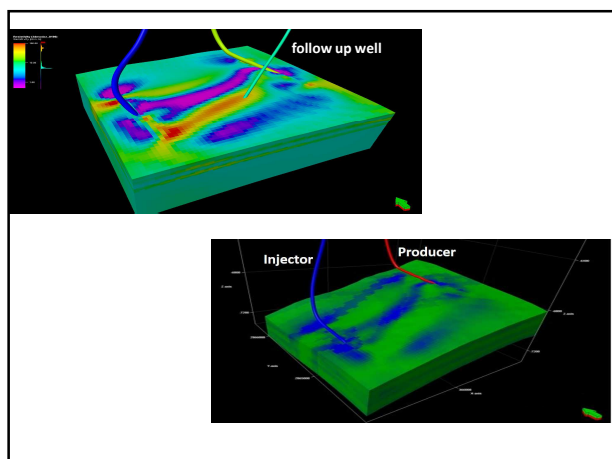




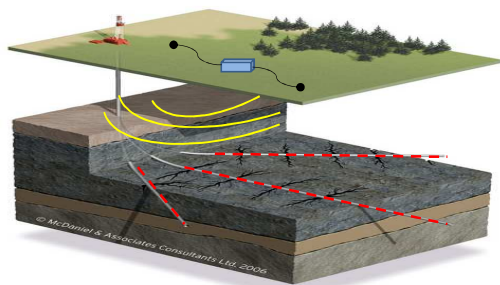








Future EM System



Conclusions

- Excellent resistivity imaging tool at reservoir scale
- Very efficient for monitoring fluid movements
- Capable to locate by-passed oil in a fractured reservoir

Thank you &
questions