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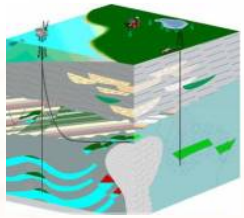
Marine time domain CSEM – Growth of and Old/New Technology

Allegar, N., Strack, K.-M., Mittet, R., Petrov, A., and Thomsen, L.

EAGE Rome 2008 Annual Meeting



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EMGS booth title:

Marine time domain CSEM – Growth of an Old/New Technology

Norm Allegar[1], Kurt M. Strack[1], Rune Mittet[2], Alex Petrov[3], Leon Thomsen[1]

[1]KMS Technologies,

[2]EMGS,

[3]Soliton/EMMET

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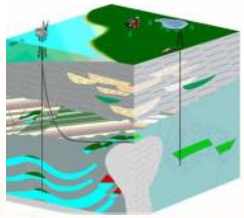
ROME 2008
LEVERAGING TECHNOLOGY



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Session Title:

Marine time domain CSEM – The first two years of experience

Allegar[1], N., Strack[1], K.M., Mittet[2], R., & Petrov[3], A.

[1]KMS Technologies,

[2]EMGS,

[3]Soliton/EMMET

ROME 2008
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Objective

Overview of 6 years of marine time domain EM

Development and introduction of tCSEM™

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Outline

- Early development of land time domain EM
- Understanding marine tCSEM™
- Data examples
- Conclusions & way forward

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Early development land time domain EM

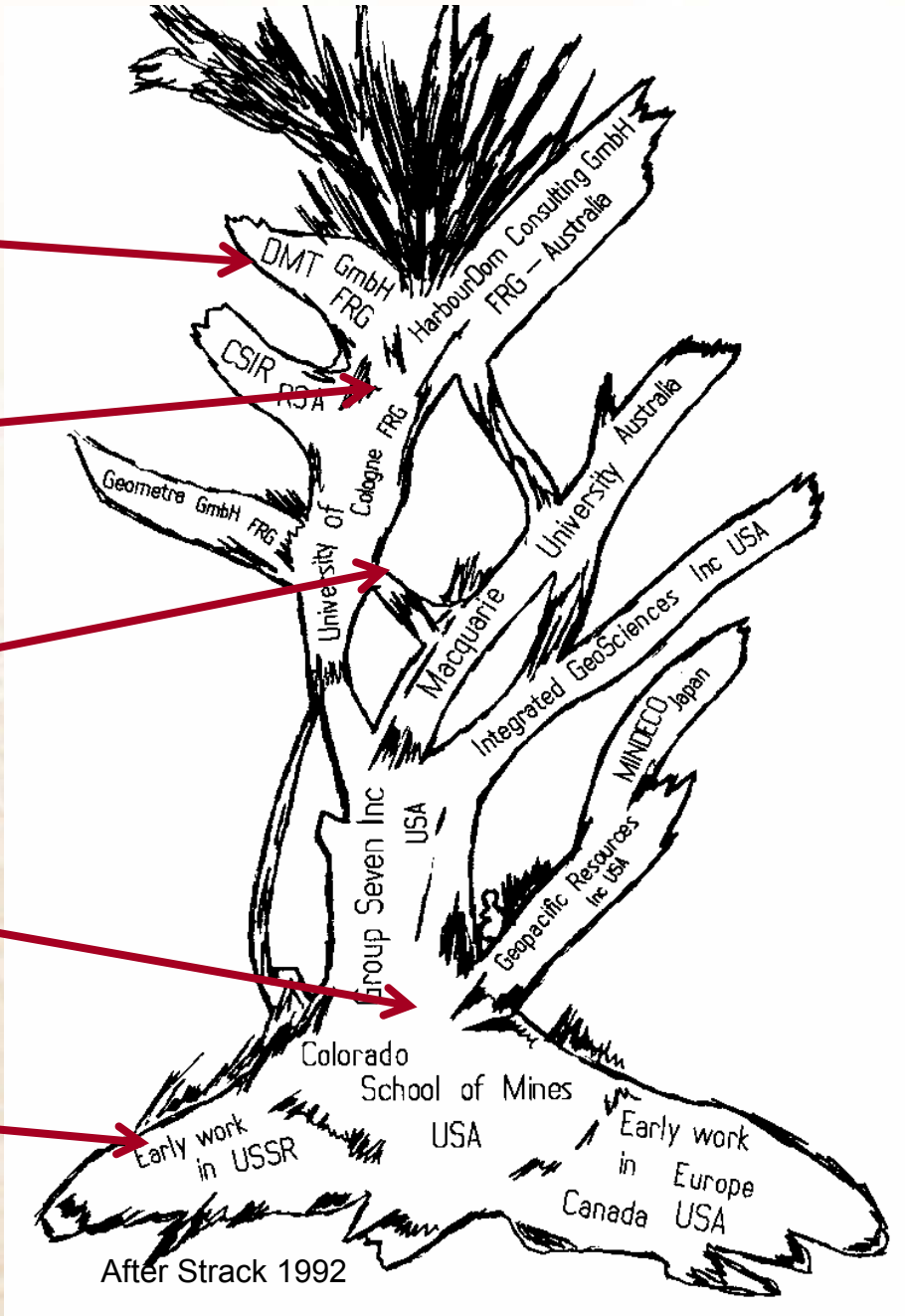
1990 – Teamex multi-channel patent spawned future systems

late 1980's – Australia & EU funded monitoring project → TU Delft & U. Edinburgh

Mid to late 1980's – electric field integrated in Australia/Germany

Early 1980's – CSM, Group Seven, IGS, Inc

1960's – initial work in Russia



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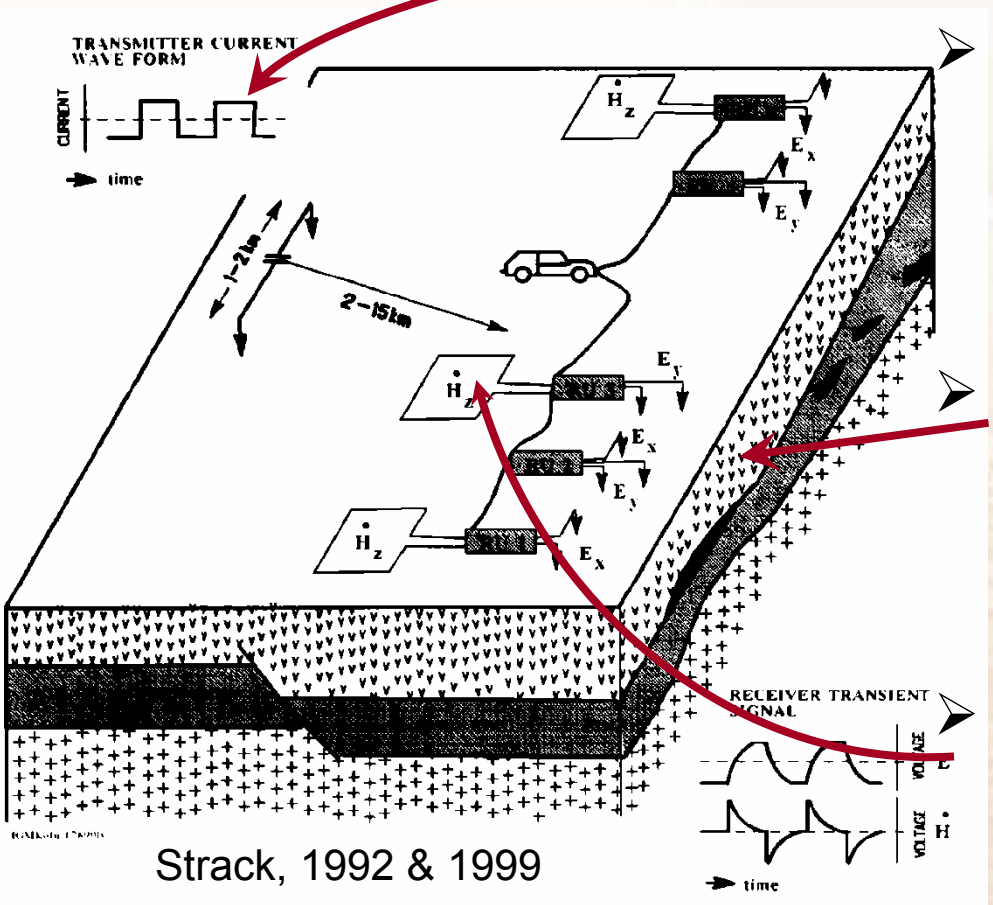
Long Offset Transient EM (LOTEM)



Strack, 1992 & 1999

Tx square wave current induces currents in Earth, penetration increases with time;

Magnetic & electrical fields induced in the subsurface

Rx measures both magnetic & electrical fields, while source is off.

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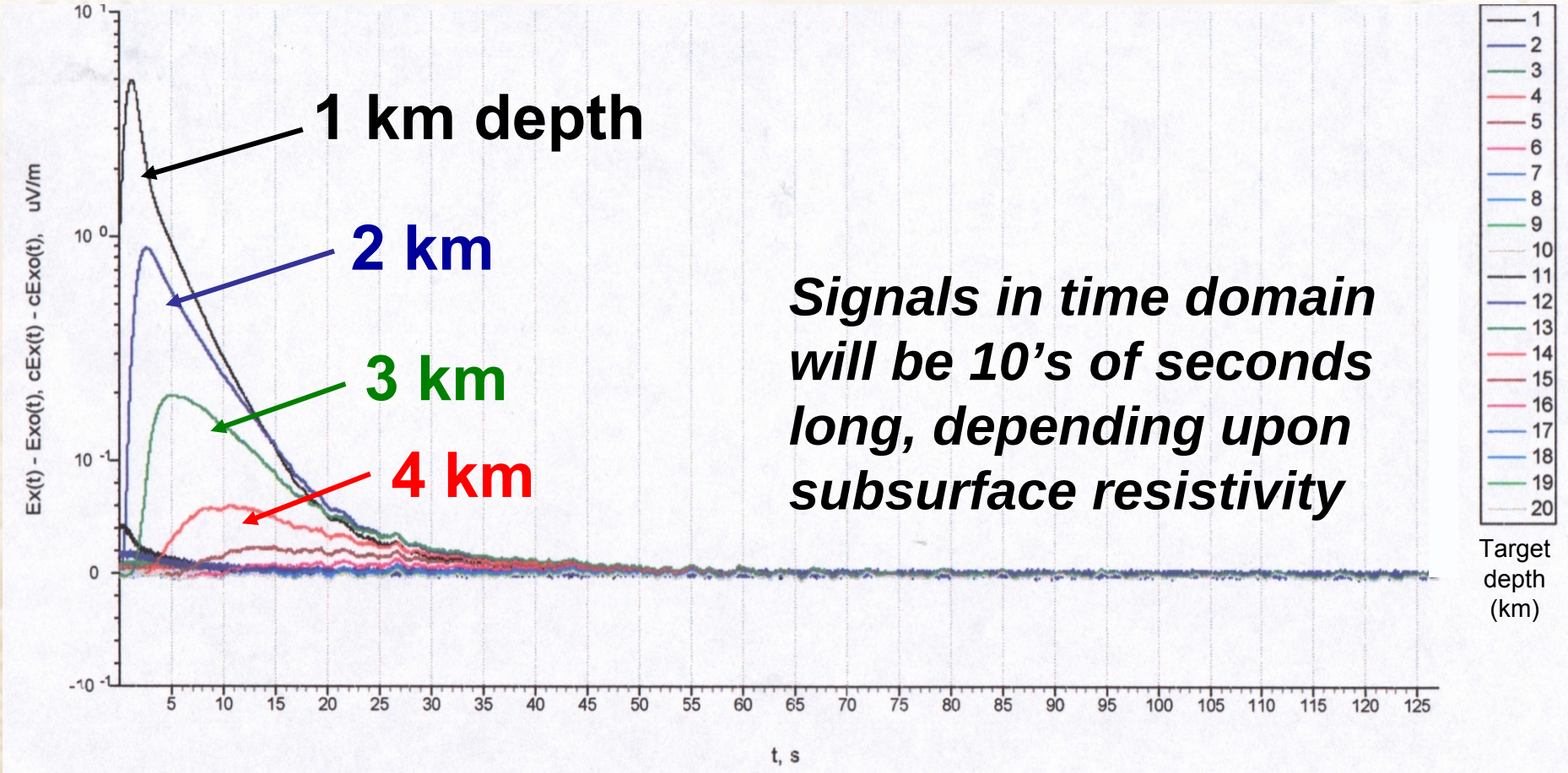
2002: predicting the time domain response

Depth of target varied: Electric fields (E_x)



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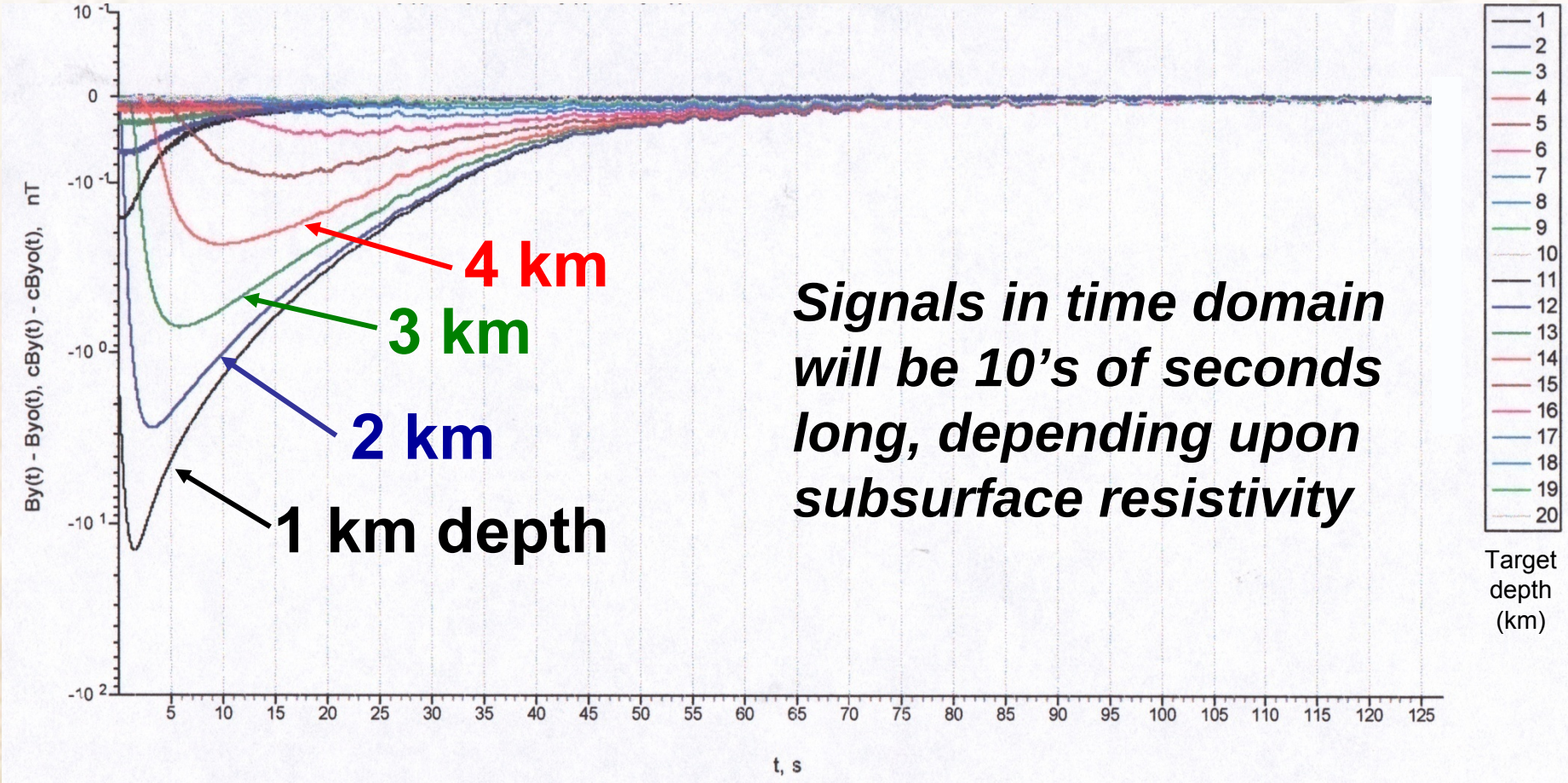
2002: predicting the time domain response

Depth of target varied: Magnetic fields (B_y)



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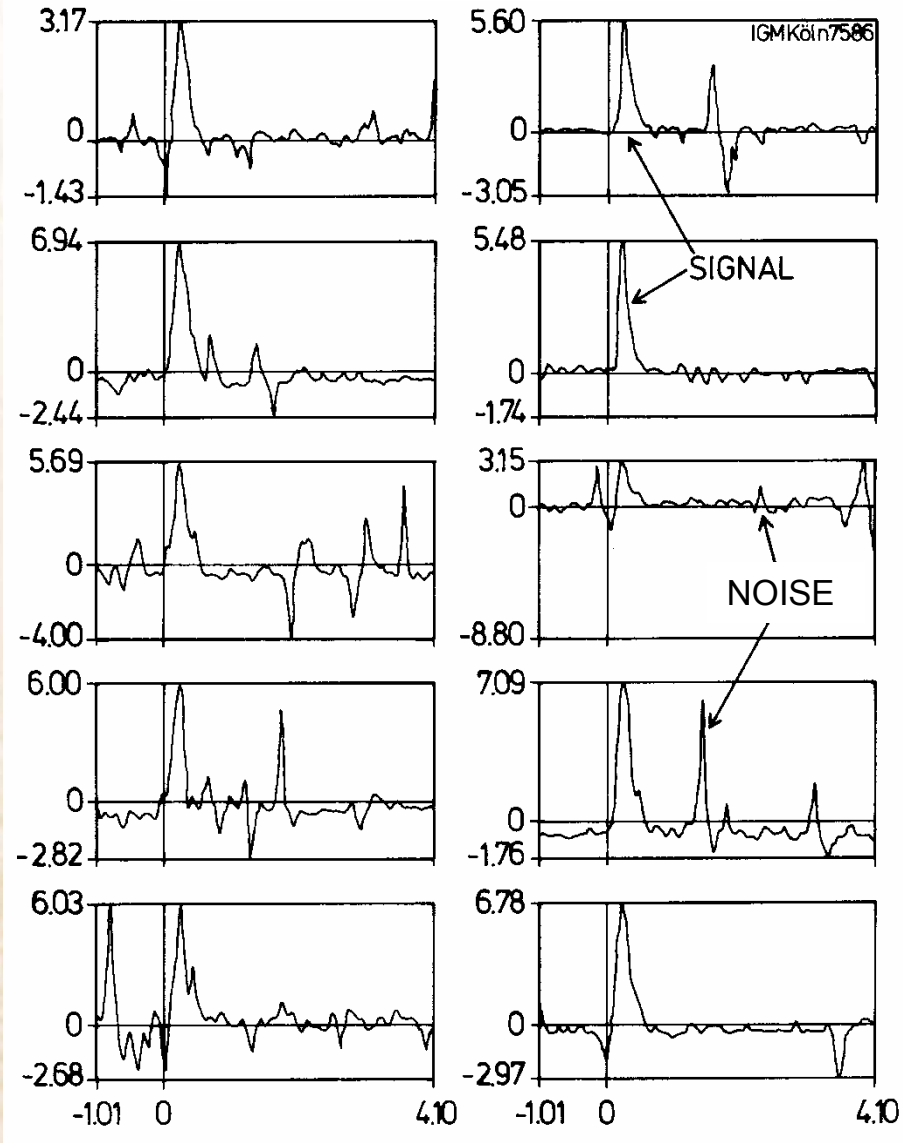
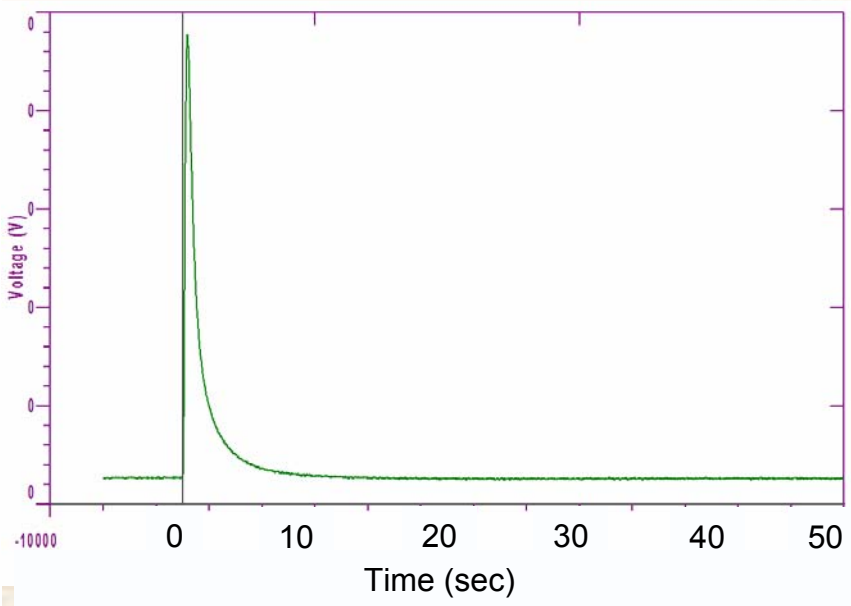
Comparing LOTEM to marine time domain data

Recorded LOTEM data (B_y)



Recorded marine CSEM data (B_y)



Measured signal = **True signal** + **Natural noise**

Significantly *less noise in marine environment*

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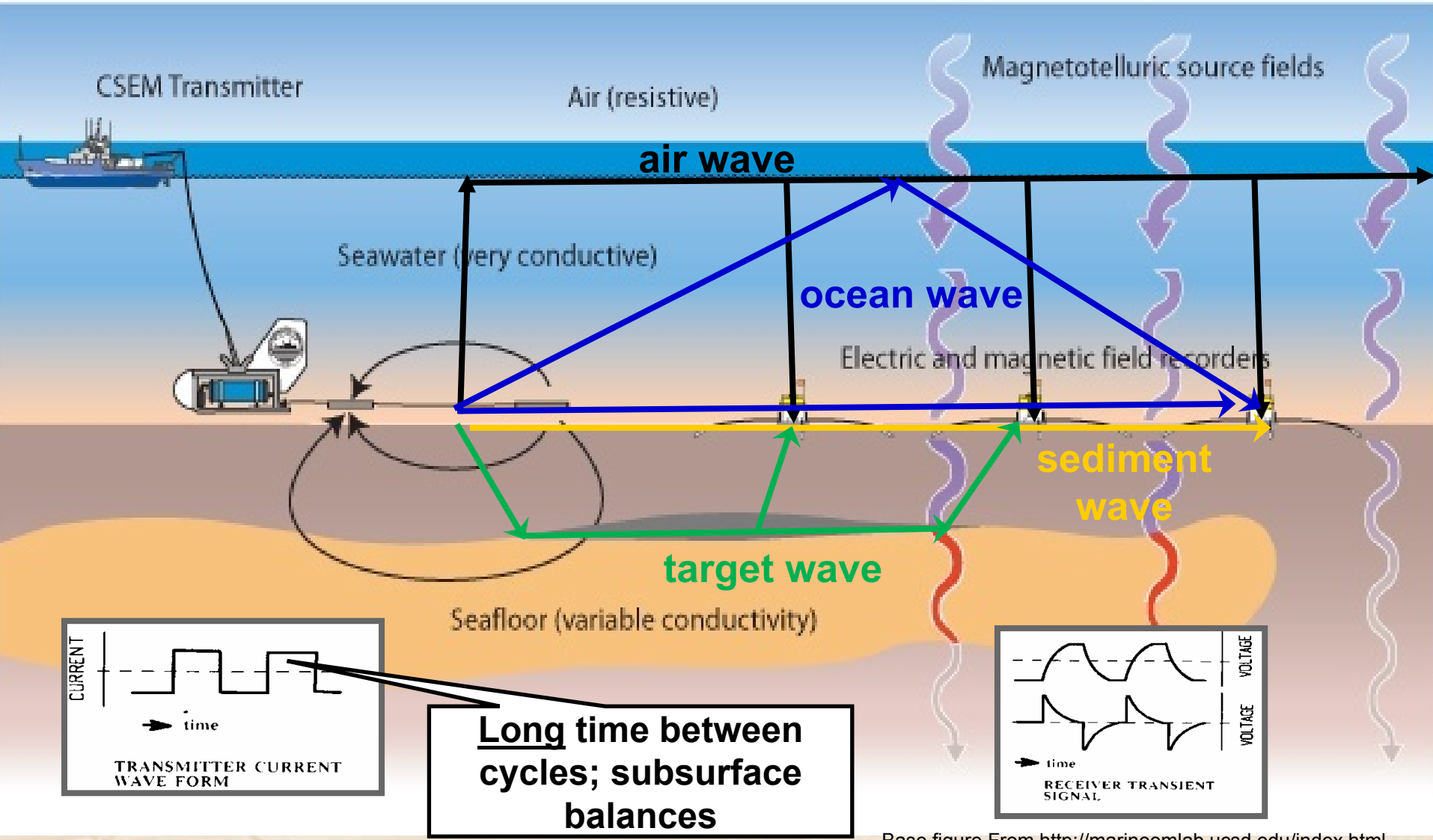
Outline

- Early development of land time domain EM
- Understanding marine tCSEM™
- Data examples
- Conclusions & way forward

Marine time domain CSEM acquisition



Long time between cycles; subsurface balances

Base figure From http://marineemlab.ucsd.edu/index.html

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Time domain CSEM 'wave' concept

- At low frequencies, Maxwell's 2nd - order equation reduces to the diffusion equation.
- The solution can be expressed as a set of *highly* damped, *highly* dispersive "waves", *with* velocity of energy similar to seismic refraction velocity (Amundsen, Ellingsrud, Mittet, 2006)
- (By contrast, the seismic wave equation has solutions that can be expressed as a set of *weakly* damped, *weakly* dispersive waves.)

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Time domain CSEM 'wave' concept (2)

- **Much of the same mathematics applies in both contexts**
- **Arrows in the cartoon should be understood as the (real parts of) wave-vectors, *not* as ray-vectors.**
- **Snell's law implies that refraction occurs at resistive layers (Eidesmo et al., 2002, Weidelt, 2007**

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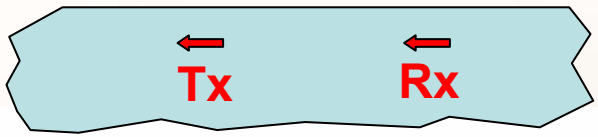
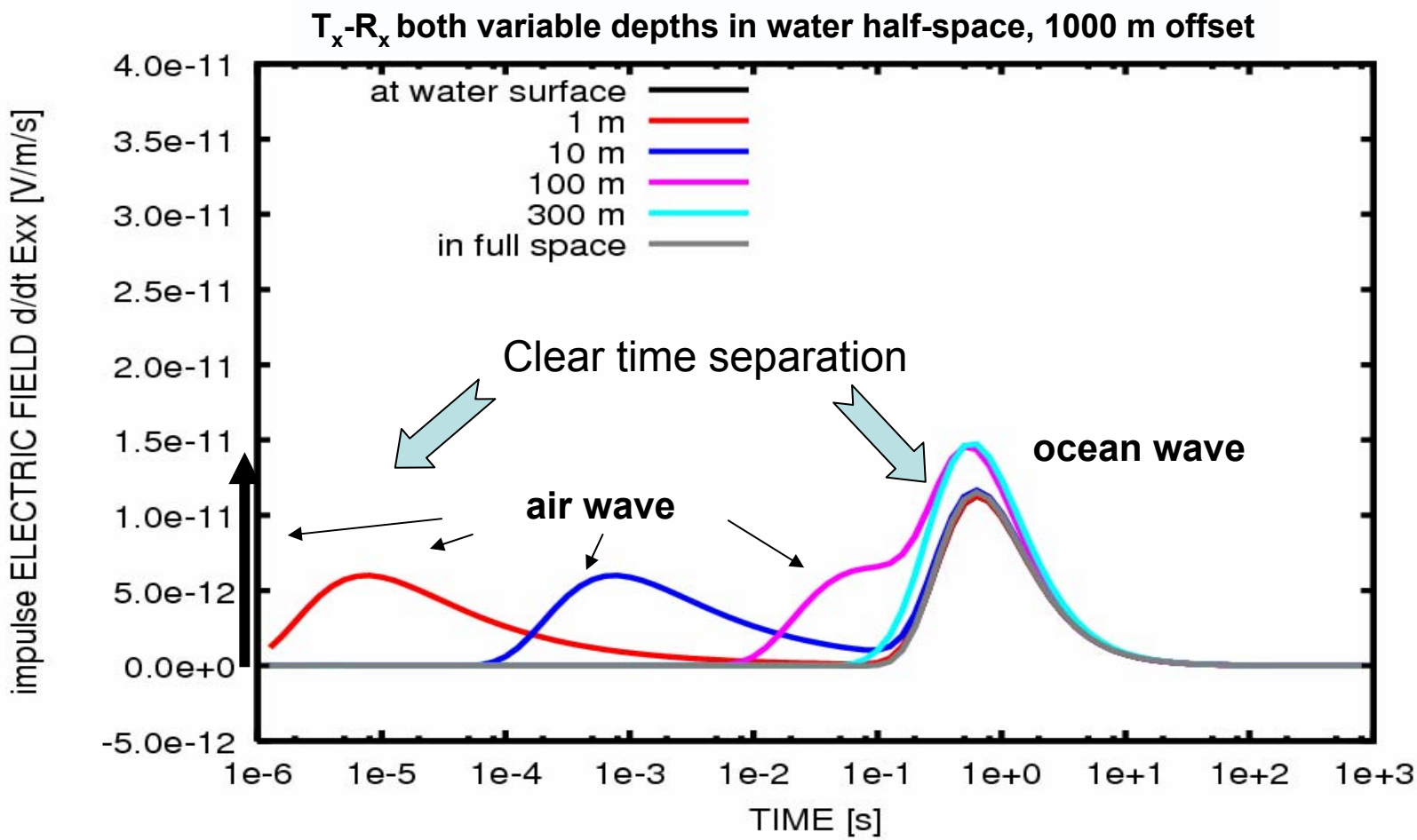
Impulse response E_x-inline



Sea depth varied



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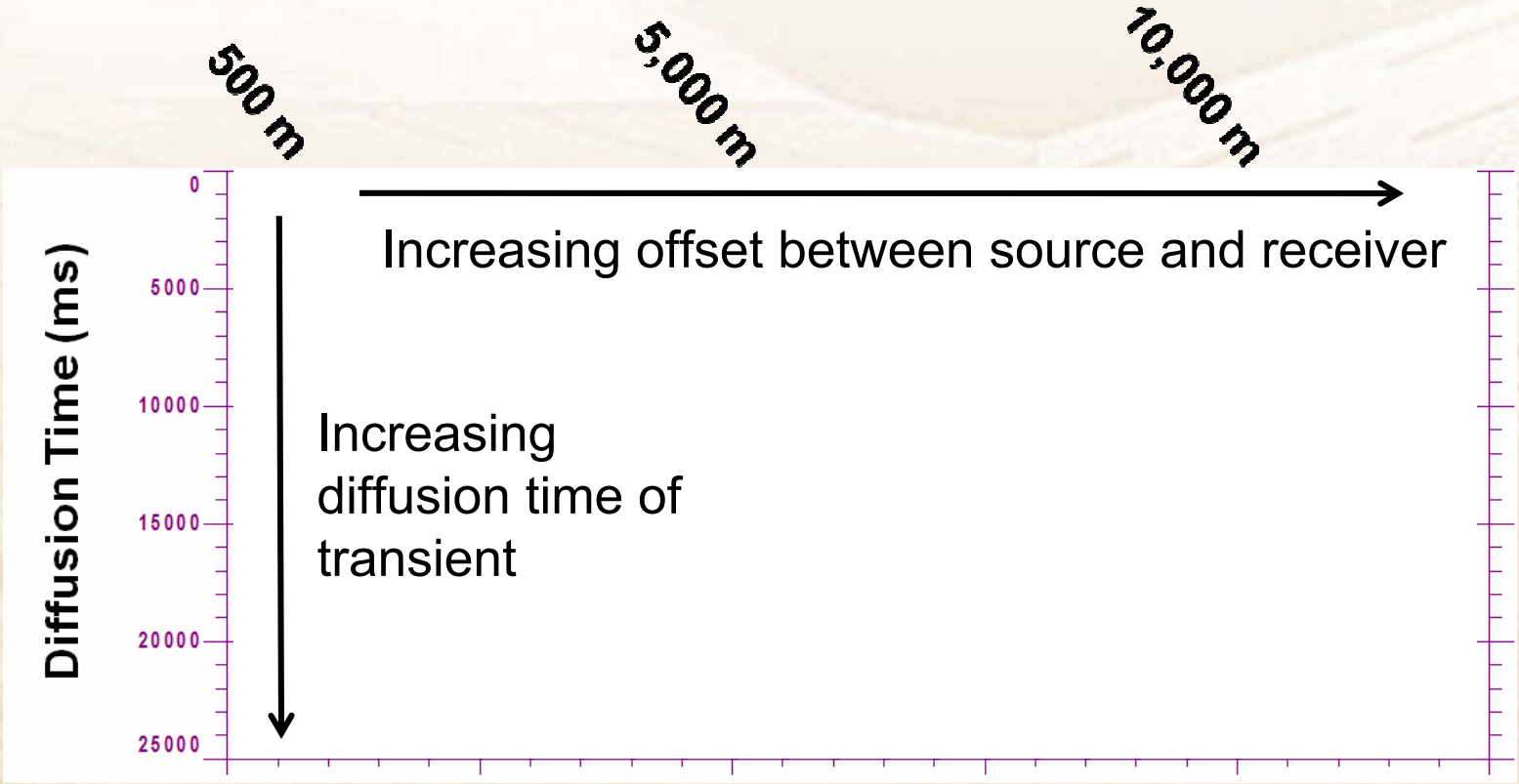
“Wave concept” with seismic style displays

With time domain CSEM we collect transients at multiple offsets



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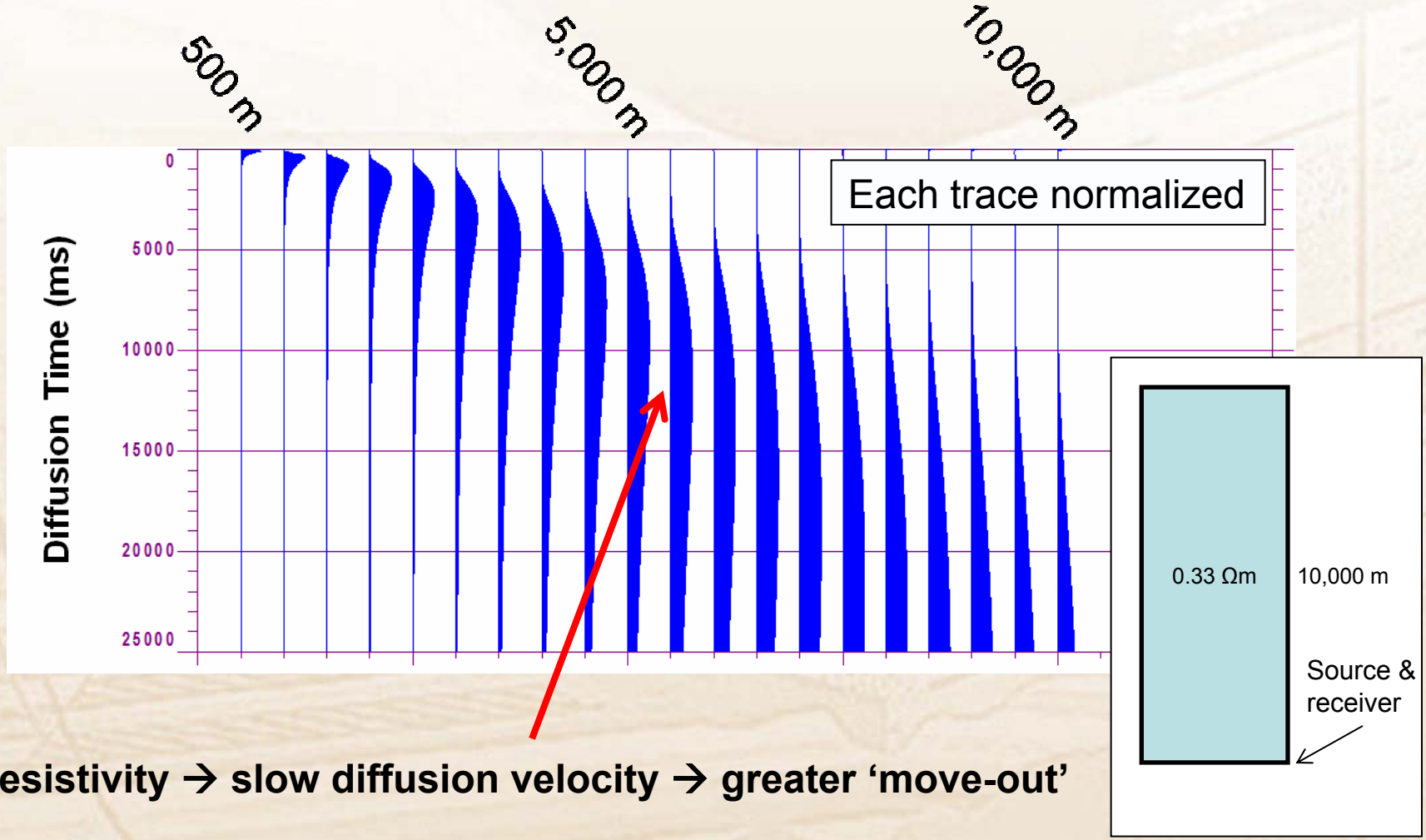
Ocean-only wave (0.33 Ωm)



Low resistivity → slow diffusion velocity → greater 'move-out'

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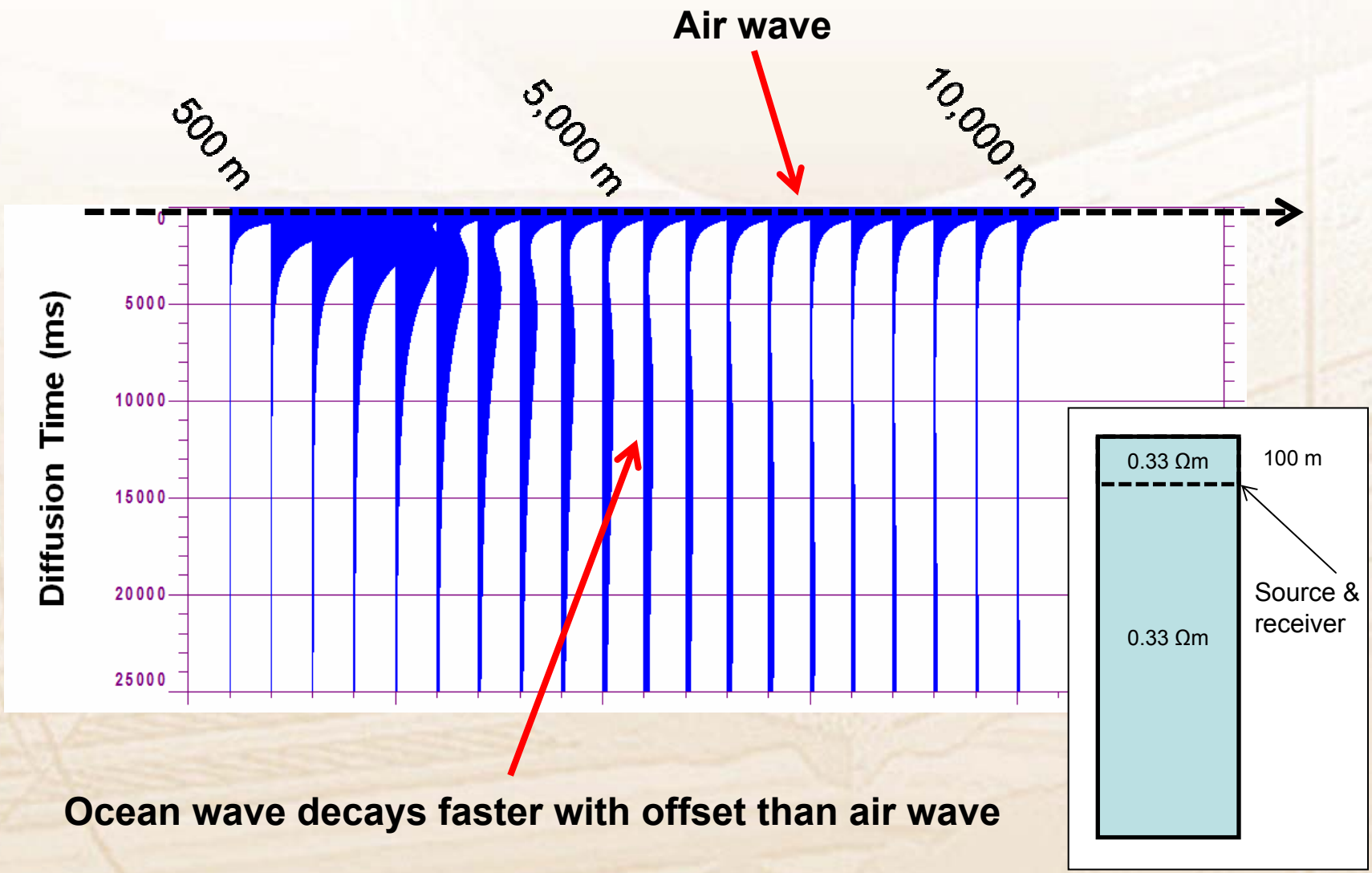
Ocean & air waves



Ocean wave decays faster with offset than air wave

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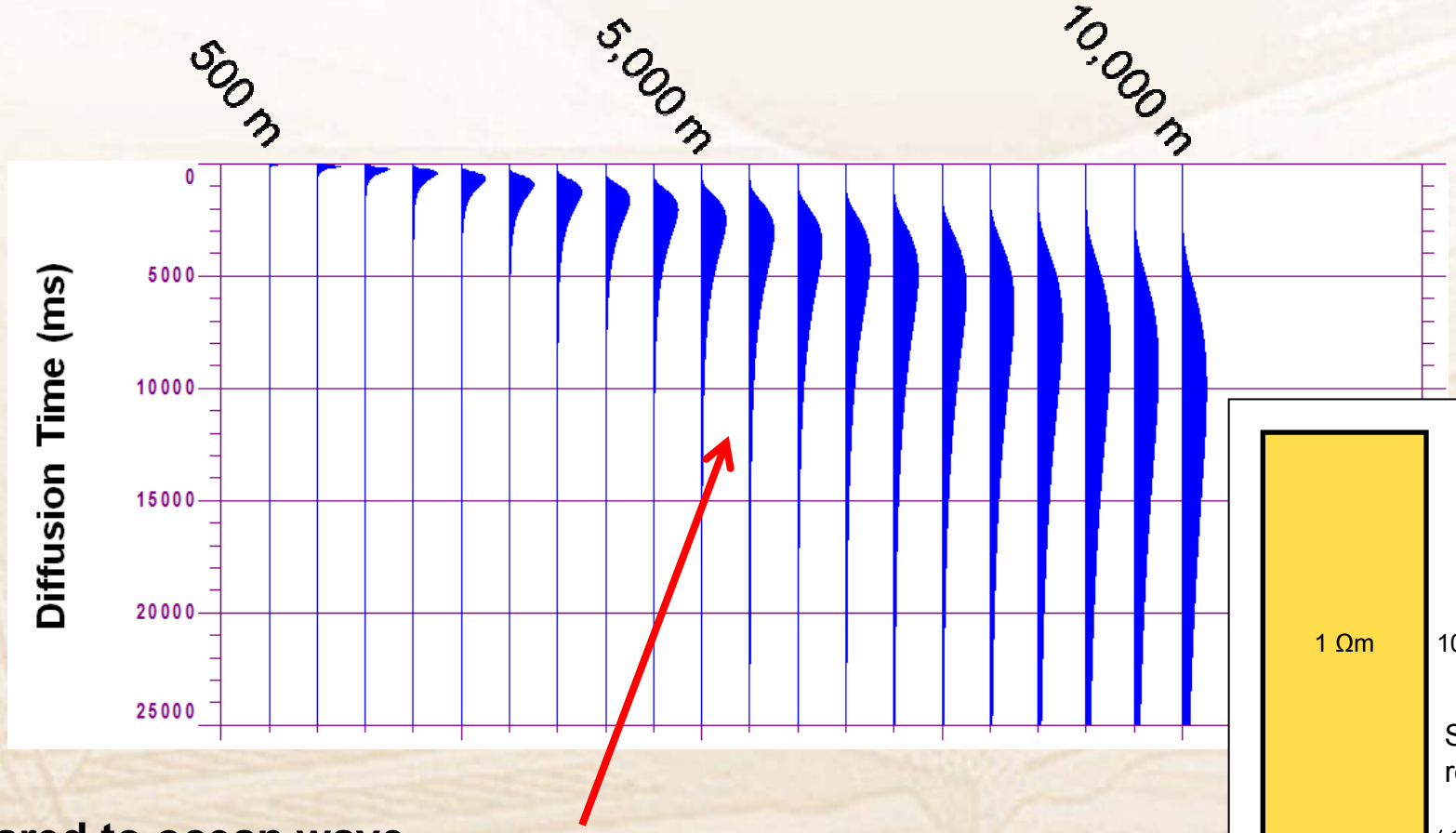
Sediment-only wave (1 Ωm)



Compared to ocean wave,
sediment wave attenuates less & arrives earlier

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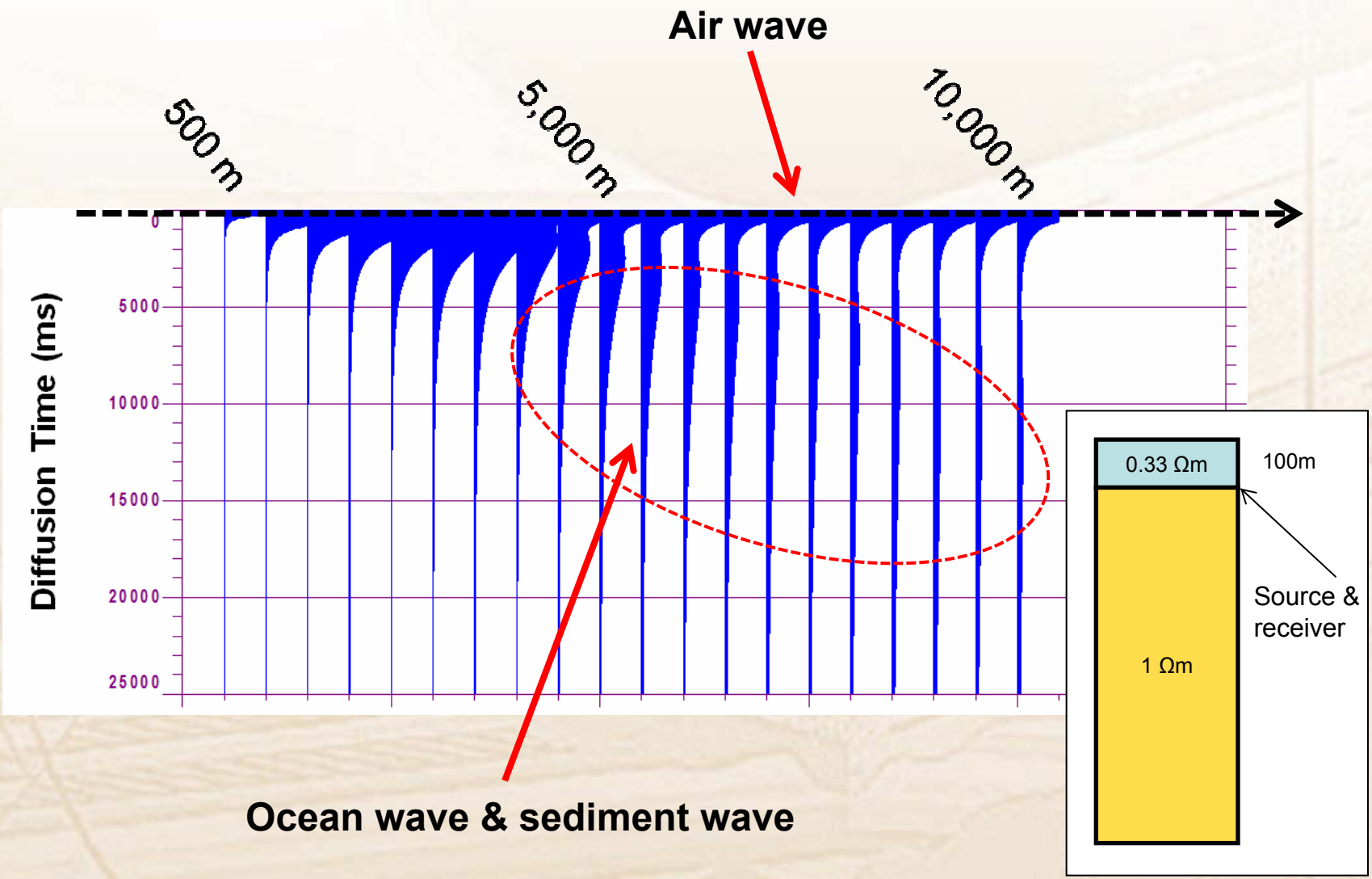
Ocean, air & sediment waves



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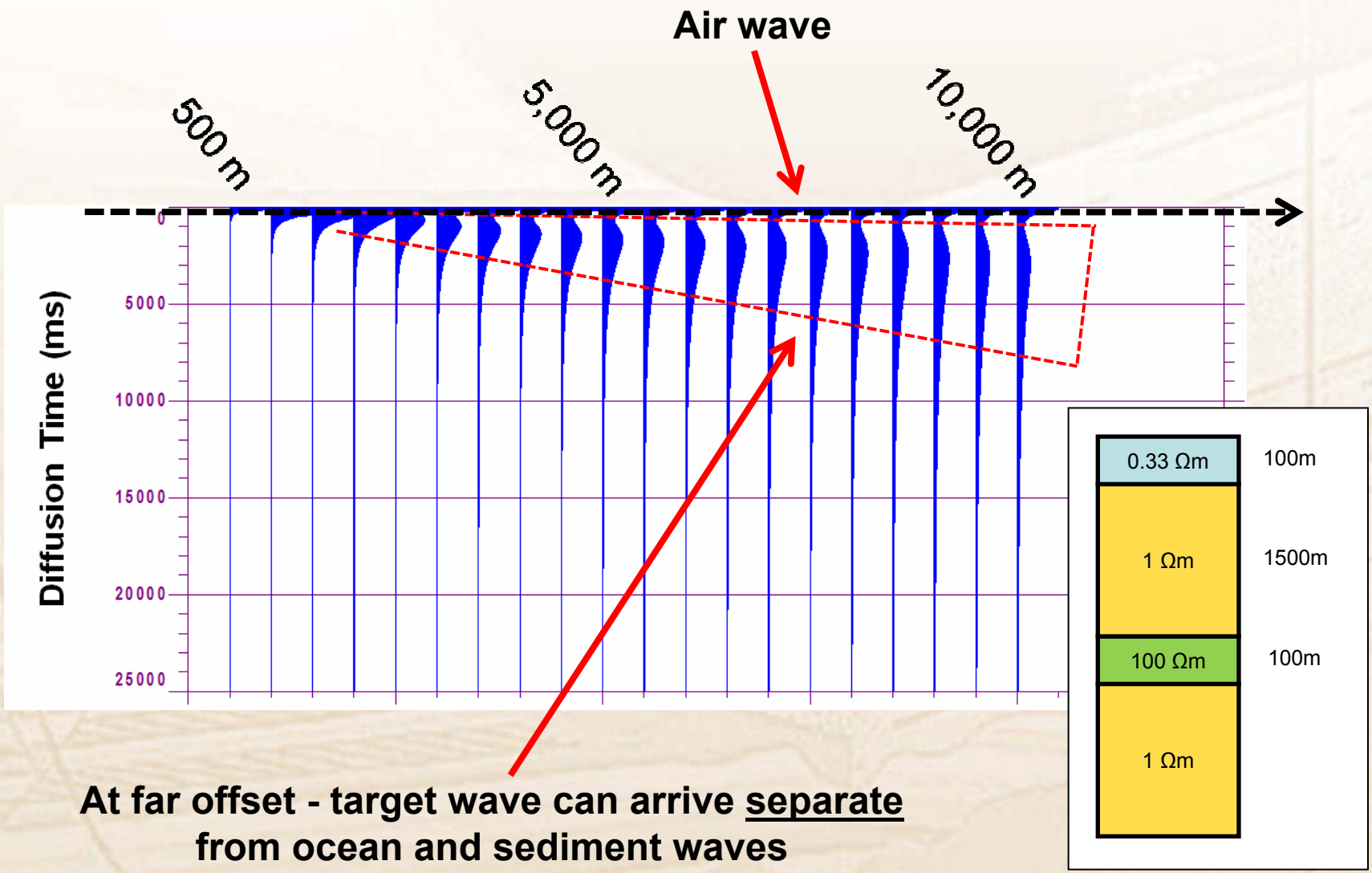
Ocean, air, sediment, & target waves



At far offset - target wave can arrive separate from ocean and sediment waves

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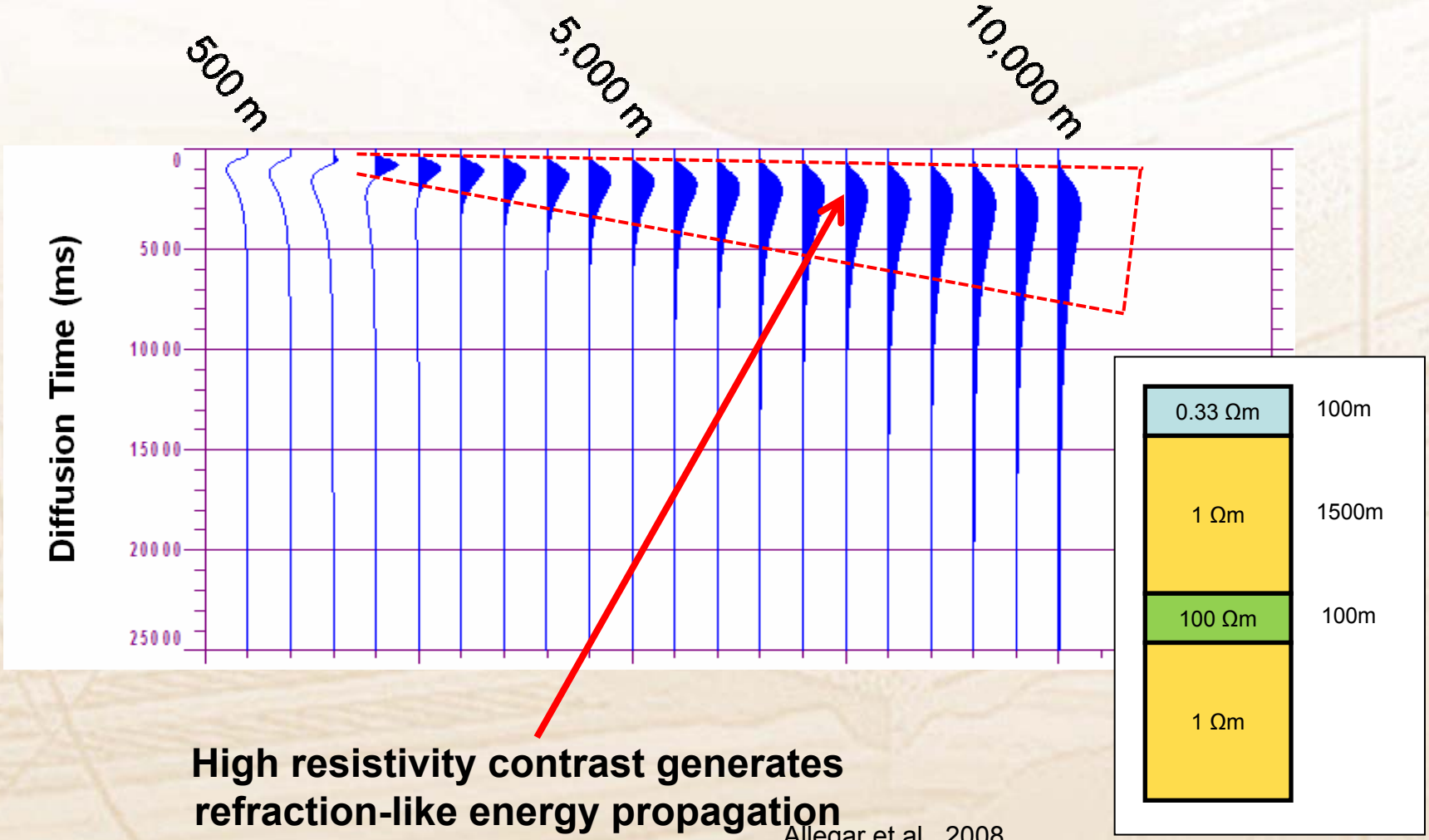
100 Ωm target-only response



High resistivity contrast generates refraction-like energy propagation

Allegar et al., 2008

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Outline

- Early development of land time domain EM
- Understanding marine tCSEM™
- Data examples
- Conclusions & way forward

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KMS/EMGS marine time domain surveys

- 2006, Egypt commercial
- 2006, Caspian Sea DOE funded
- 2007, Gulf of Mexico (2) commercial
- 2008, North Sea commercial

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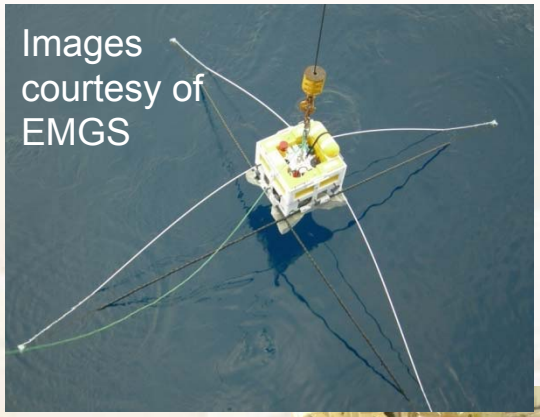
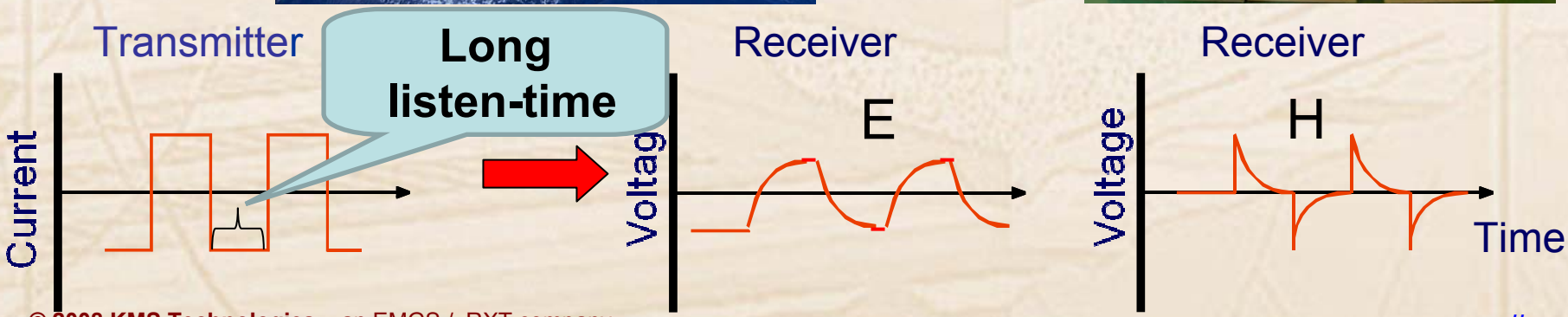
Time domain CSEM collected with commercial nodal acquisition system





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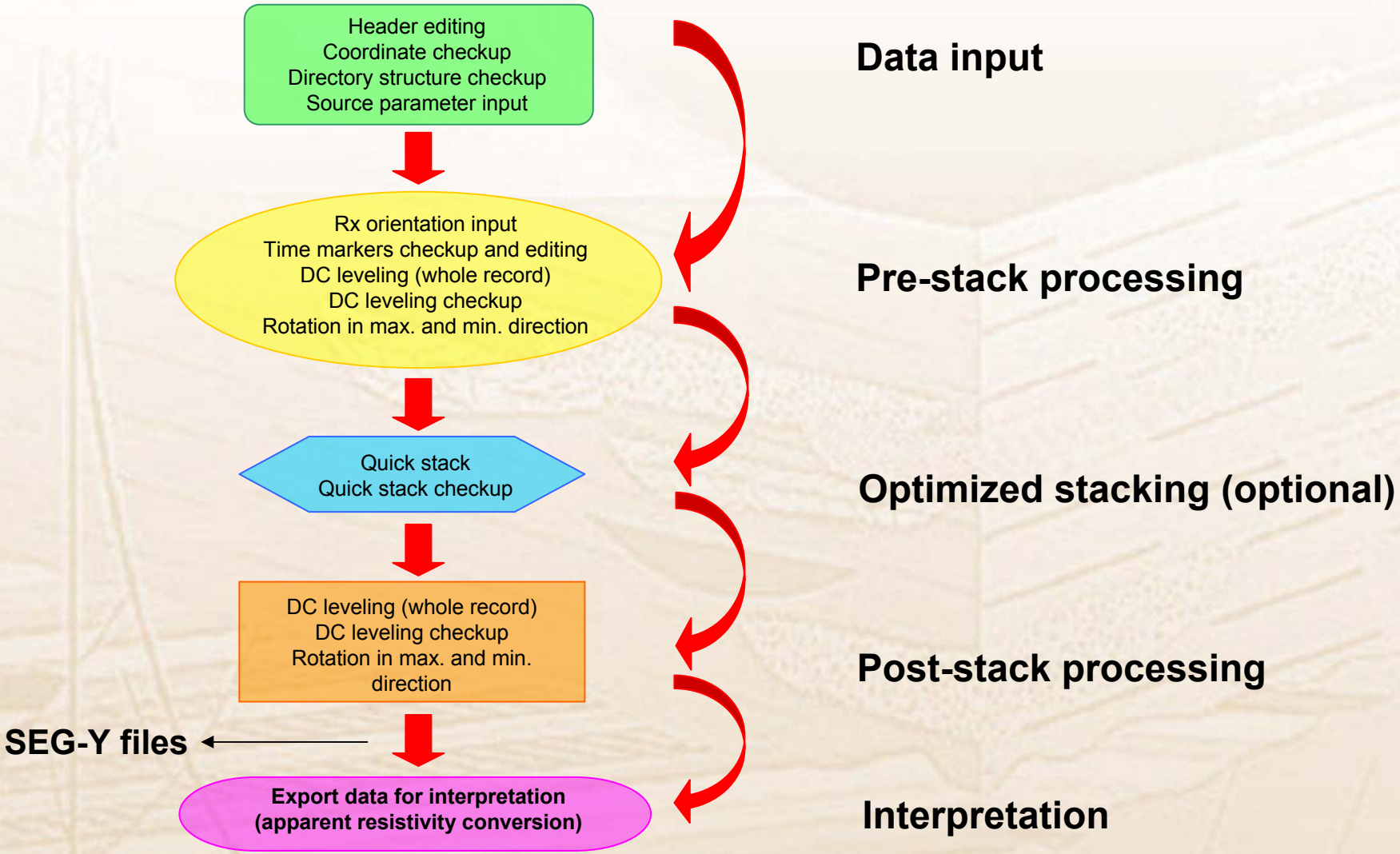
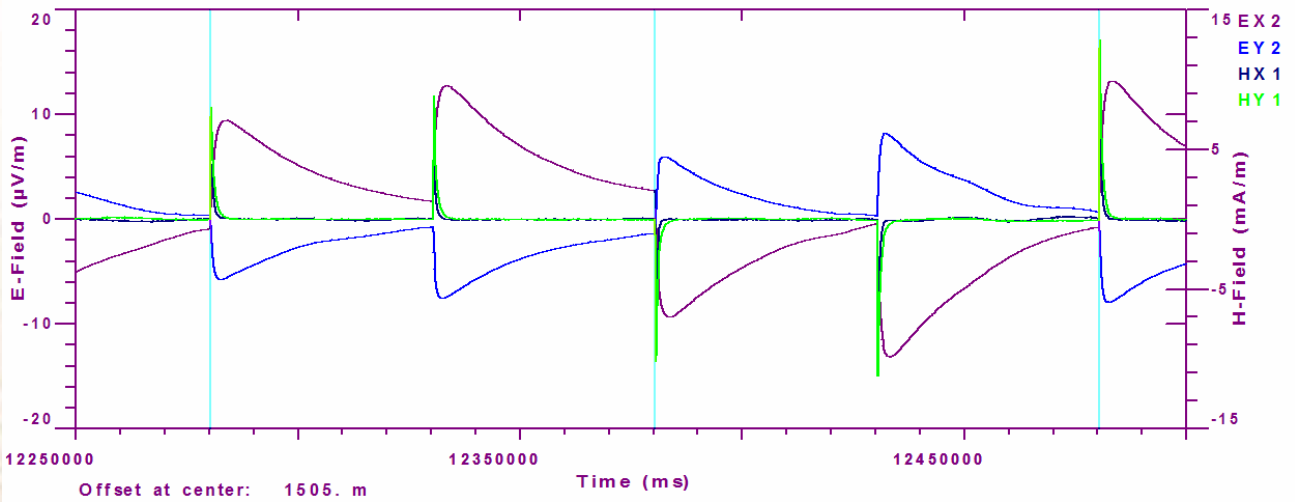
Data processing: general flow



Data processing: rotation

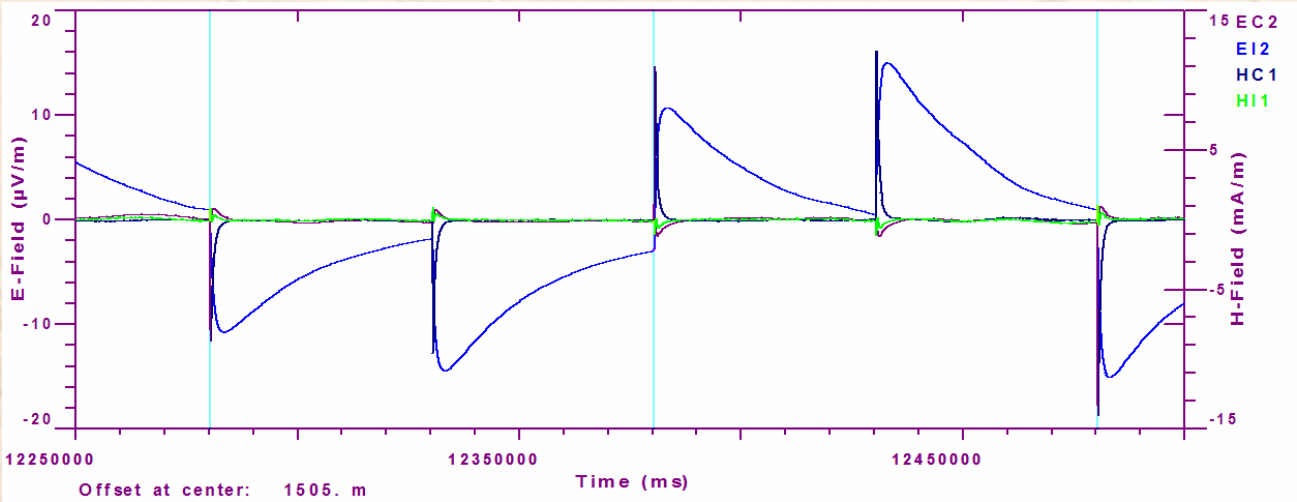
- Before rotation

(Ex,Ey,Hx,Hy)



- After rotation

(EI,EC,HI,HC)



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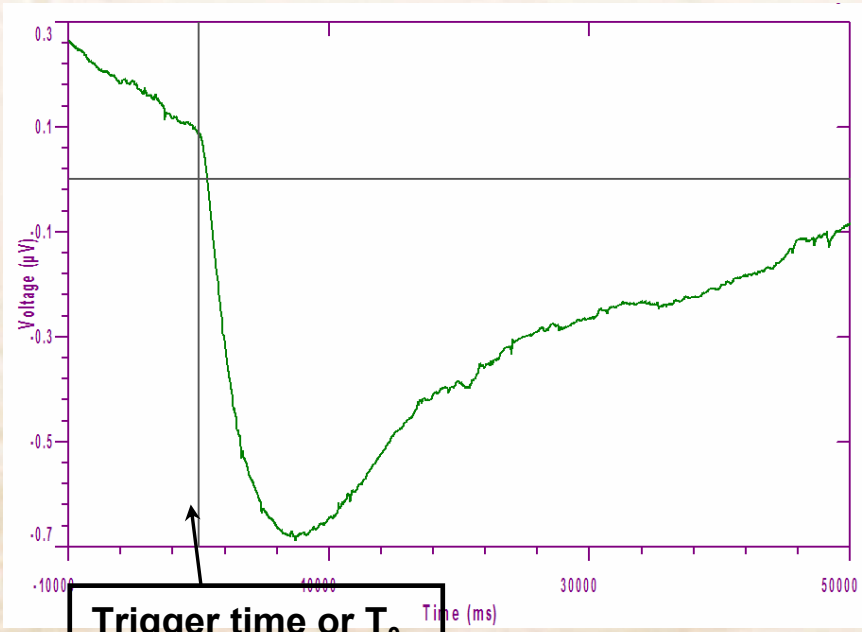
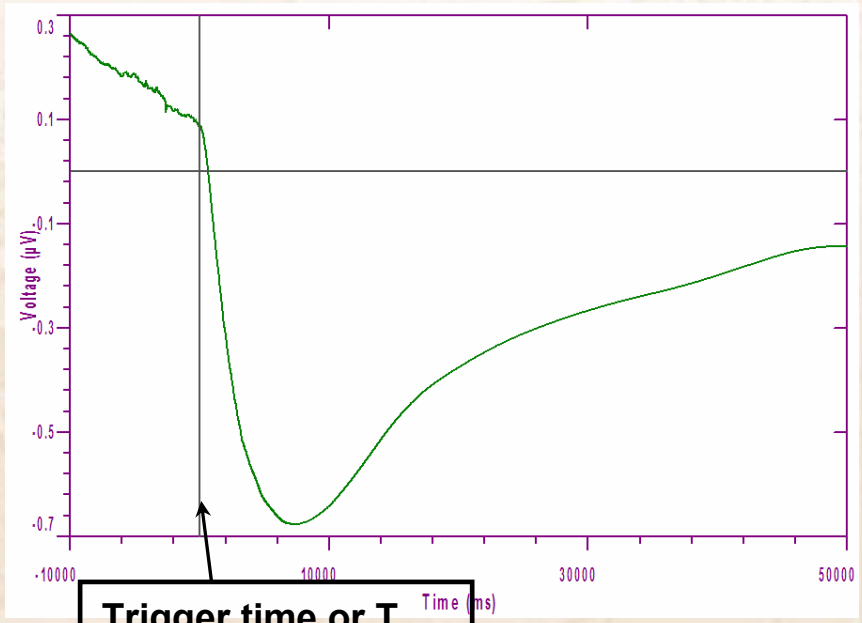
Data processing: smoothing

- Smoothing of transients where necessary:

- Before smoothing



After



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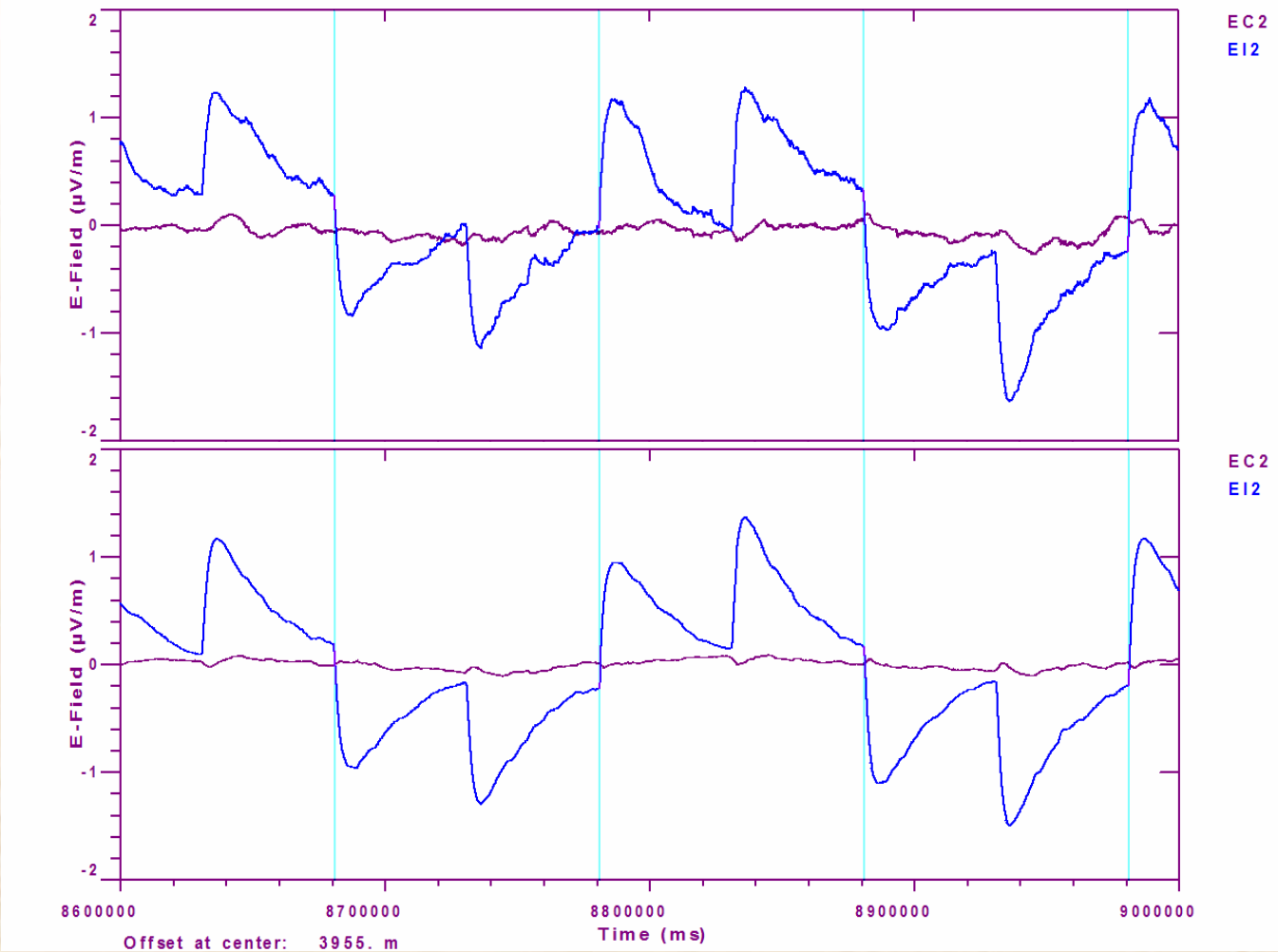
Data processing: stacking (horizontal)

- Pre-stack
- Post-stack



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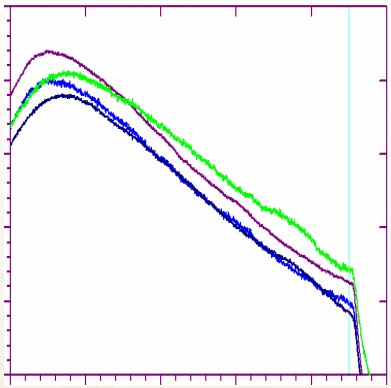
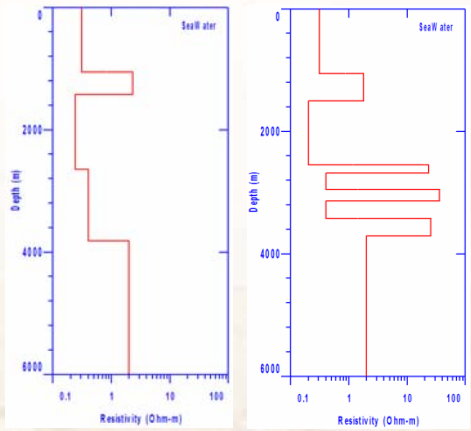
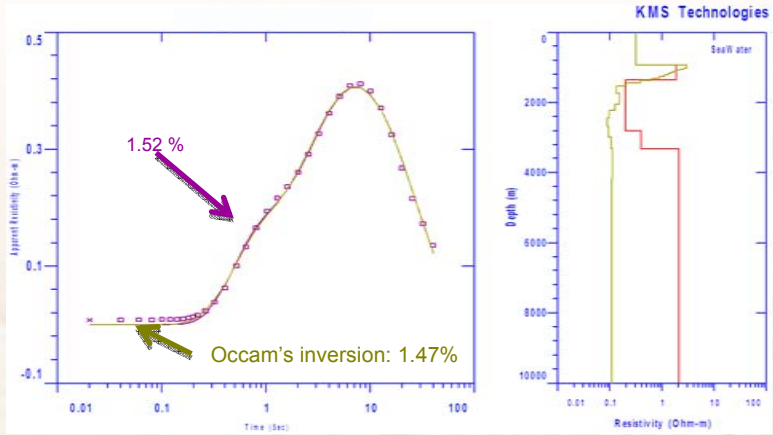
Interpretation: inversion



Transient

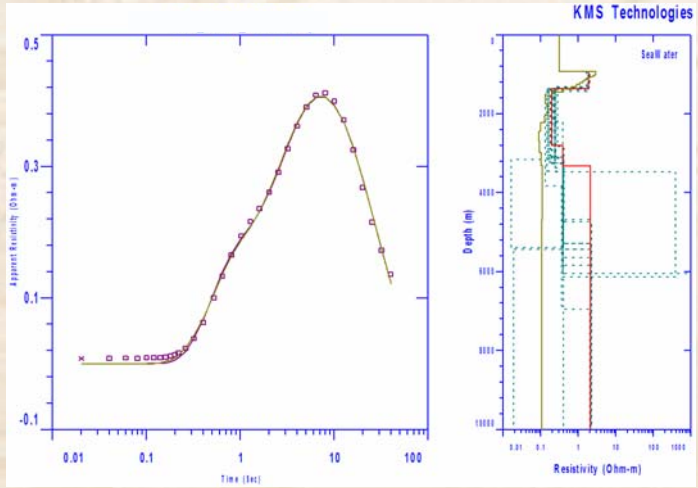


Starting models



Inversion of data

Testing inversion robustness



- Locate resistors
- Identify hydrocarbons

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Outline

- Early development of land time domain EM
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Conclusions & way forward

- High quality marine transient CSEM has been successfully collected
- The data matches theoretical anticipations
- Transient CSEM data offers a complementary solution to the shallow water CSEM problem
- Seismic style processing may hold promise for isolating the target wave
- Research is continuing aggressively.

Acknowledgements

- We would like to thank
  EMGS & KMS Technologies
  for permission to show these results

- By the time that
  you get home,
  this presentation
  will be posted on
  http://KMSTechnologies.com

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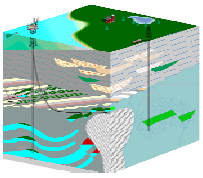

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