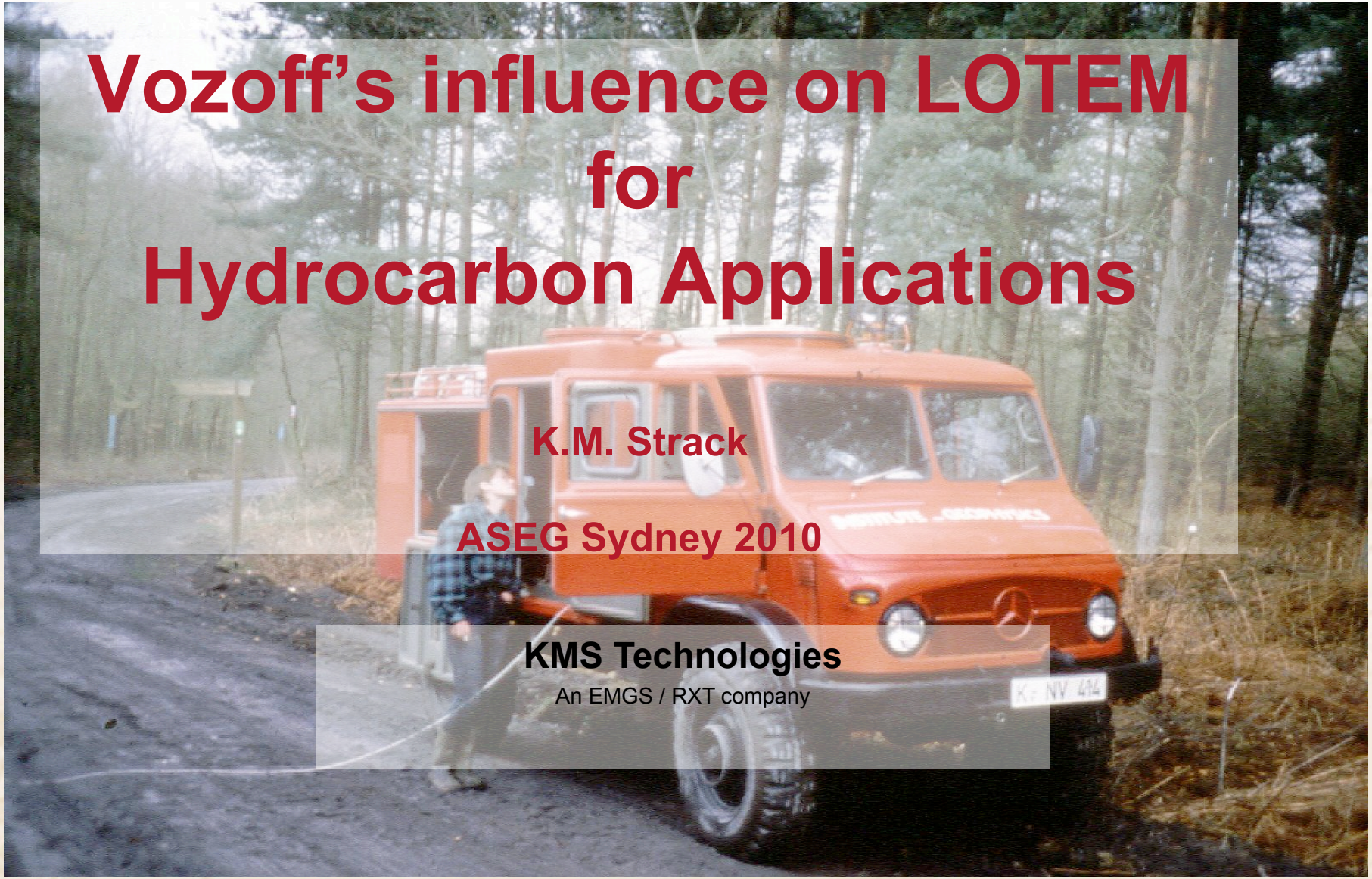
KMS Technologies – KJT Enterprises, Inc.
An EMGS/RXT company

Vozoff's influence on LOTEM hydrocarbon applications

Strack, K.M.

21 ASEG Conference and Exhibition, Sydney
2010

Vozoff's influence on LOTEM for Hydrocarbon Applications



K.M. Strack

ASEG Sydney 2010

KMS Technologies

An EMGS / RXT company

www.KMSTechnologies.com

Vozoff's influence on LOTEM for Hydrocarbon Applications

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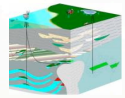
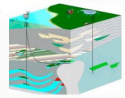
Agenda



- Historic background
- Resolving resistive layers
- Mapping porosities
- Inversion up and down

Agenda



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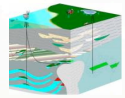
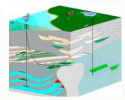
History



- 1981 First involvement via Ph.D. student
- 1983 First Lotem measurements in Australia
- 1984-5 NRDC/Esso Lotem project
- 1980s collaboration w/ Uni Cologne
- 1992-8 Humboldt award to Keeva, Germany visits, EU project→MTEM, Australia Lotem projects, retirement
- 1996 Summary publication: Integrating Lotem with seismics

- FOCUS: Integration with seismic, ANISOTROPY, thin resistors, porosity mapping

Agenda



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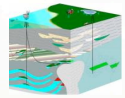
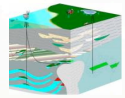
Resolving resistive layers



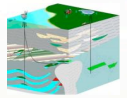
- Initial work at U of T and CSM (Eadie, 1979 and Passalacqua, 1979). M.Sc and Ph.D. thesis.
- Vozoff et al. 1989. First land CSEM case histories
- TODAY: Eidesmo et al. 2002, Ellingsrud et al. 2002. Marine NOW successful

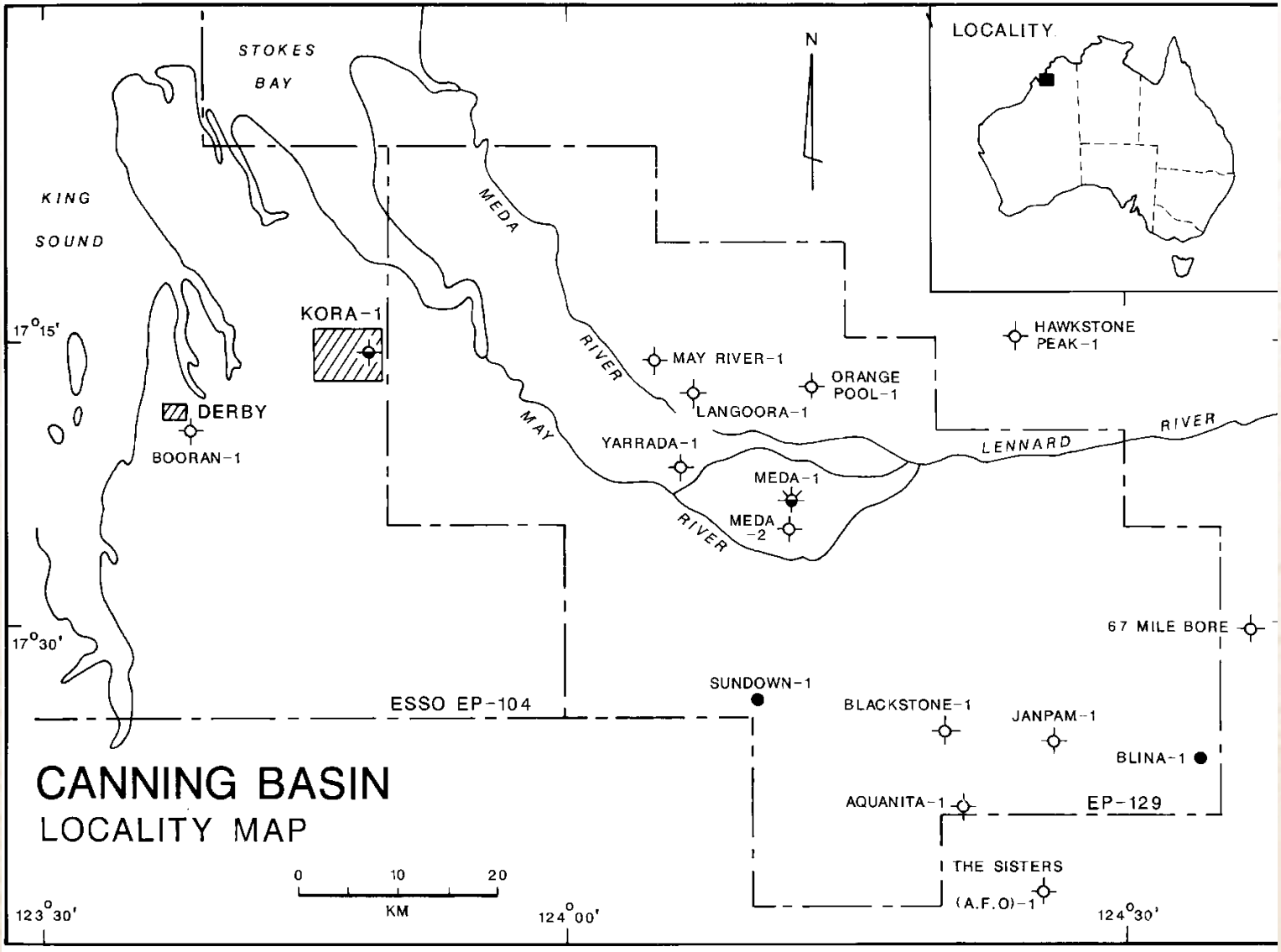
Australia: Punch line



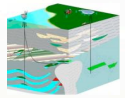
- Work was funded by Australian government & Esso
- Objective was mapping porosity variations in carbonate: World's first field trial
- Work done using modified commercial equipment
- Interpretation done by Esso staff

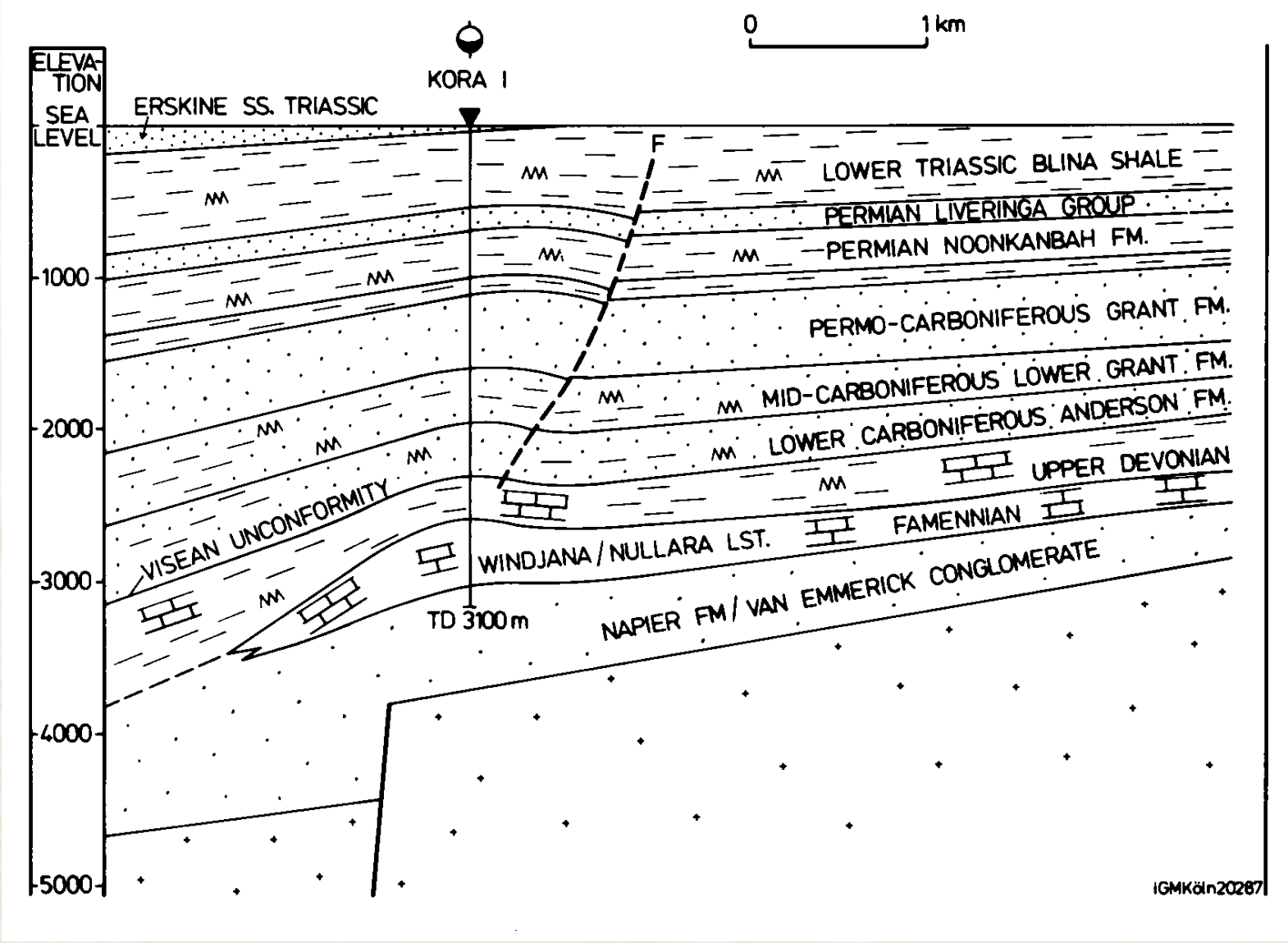
Canning Basin, Australia basemap



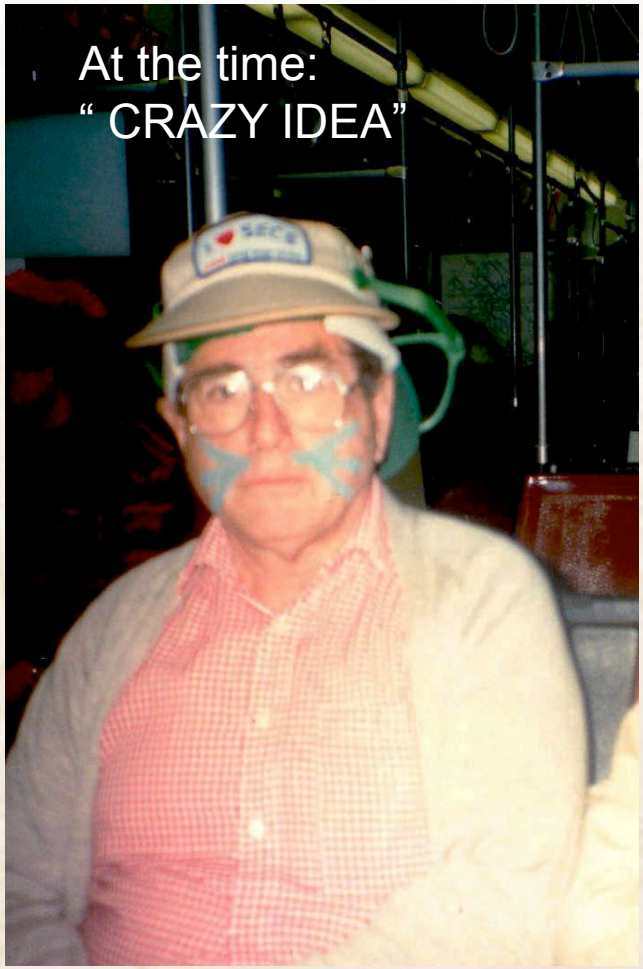


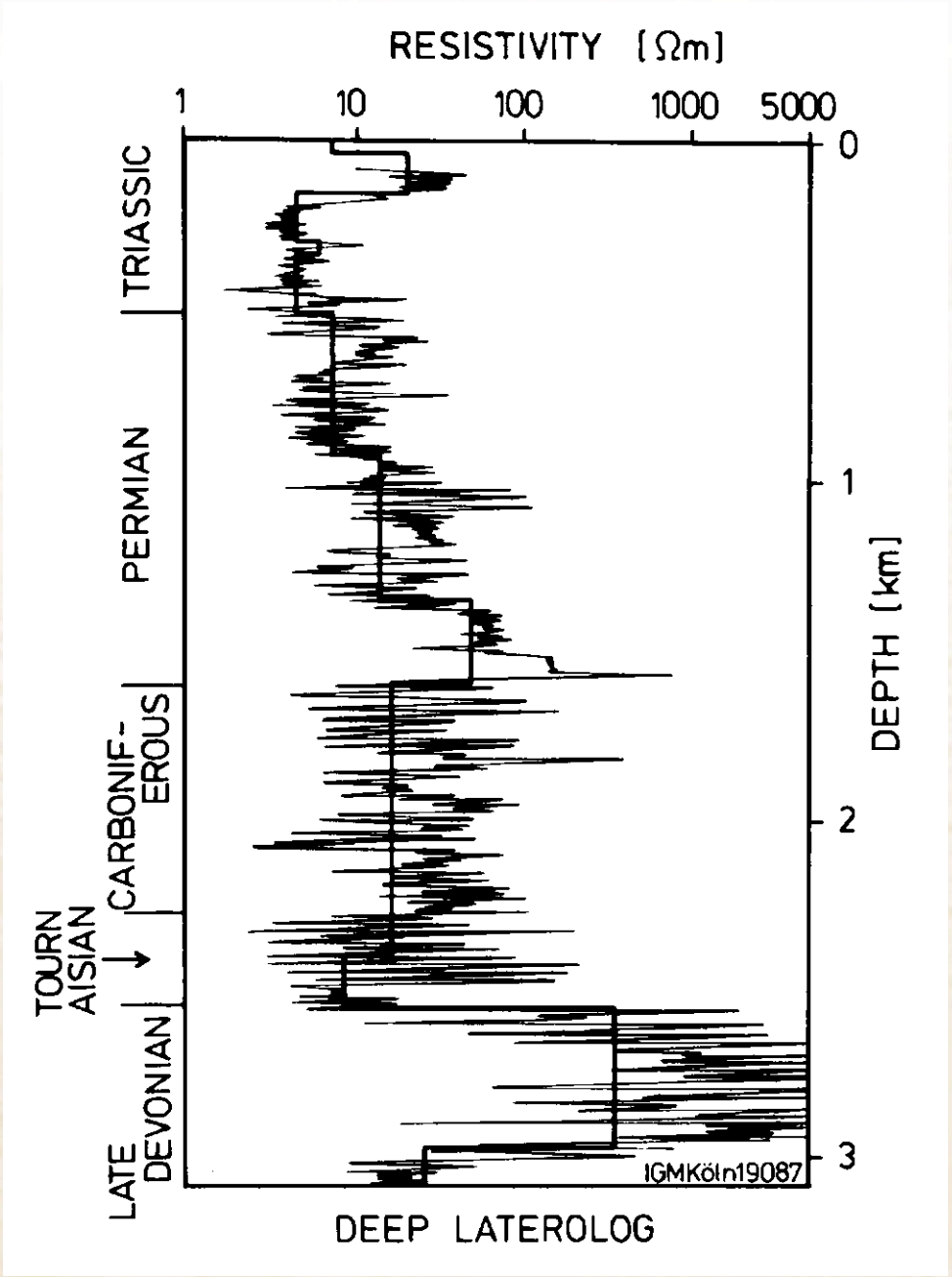
Canning Basin: geologic section



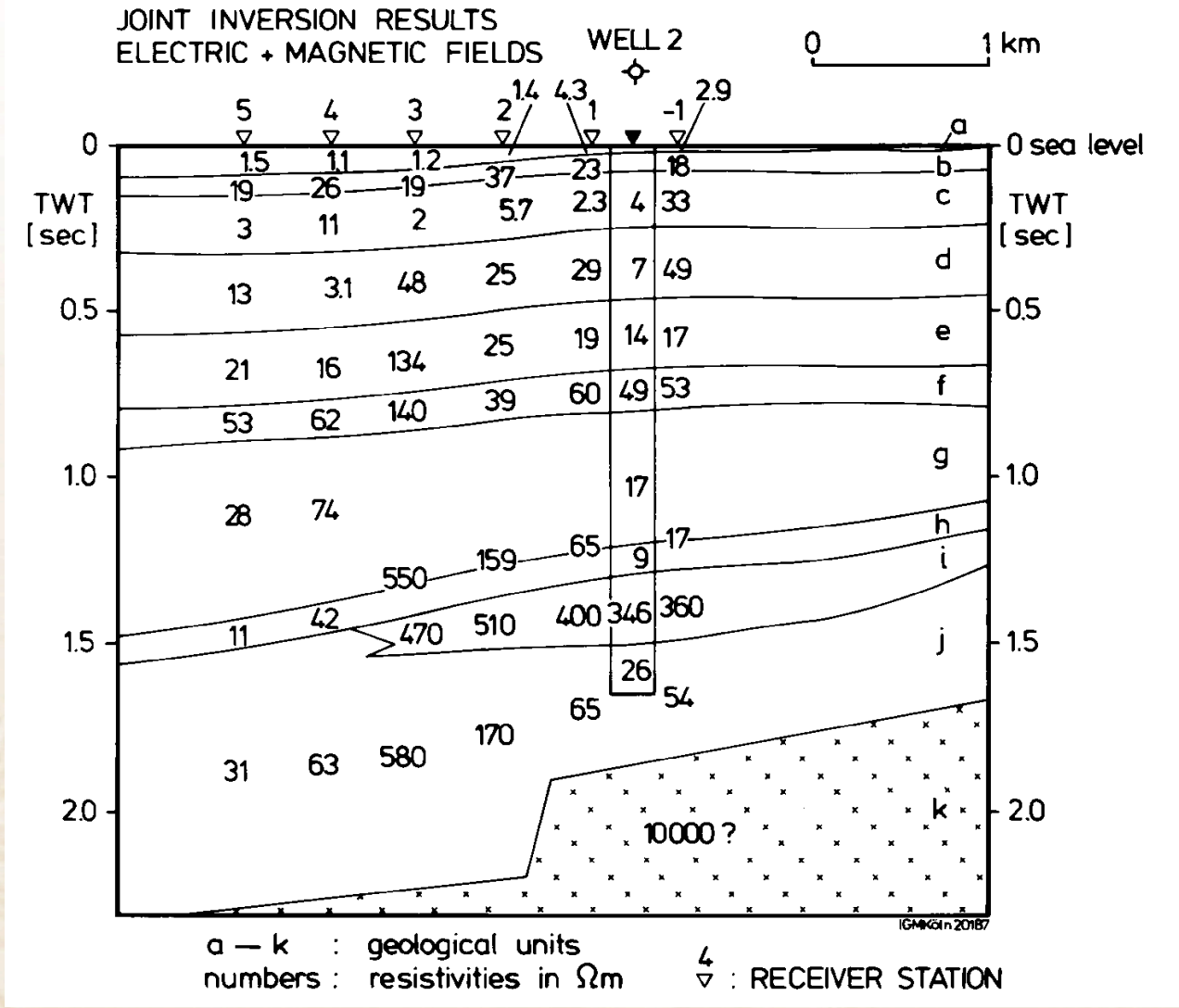


Canning Basin: well 2..log

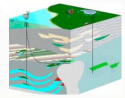




Canning Basing: joint inversion results

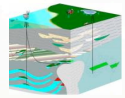


Australia results



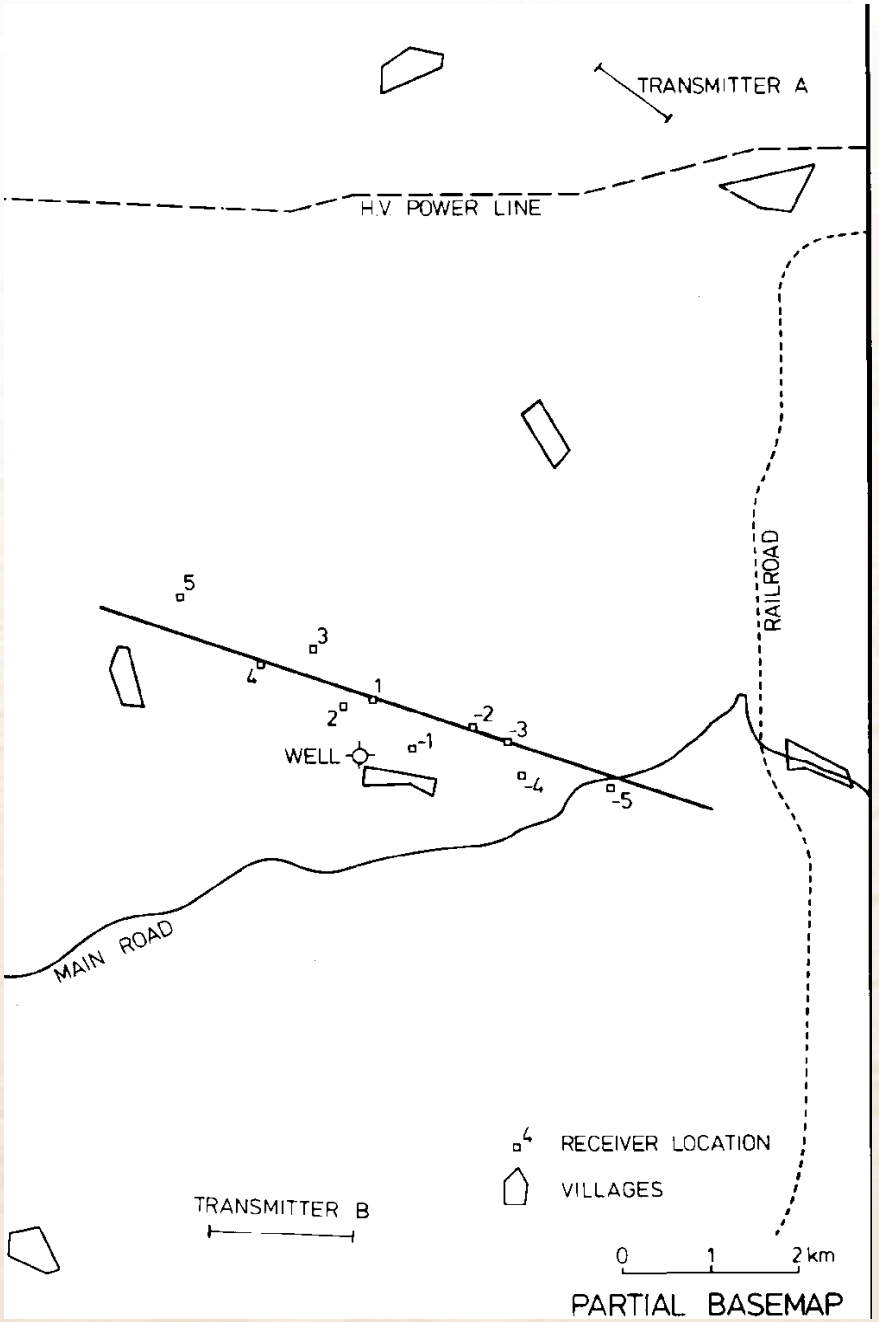
- Mapped resistivities but NO porosity changes
  → great to get release to publish

Germany: punch line



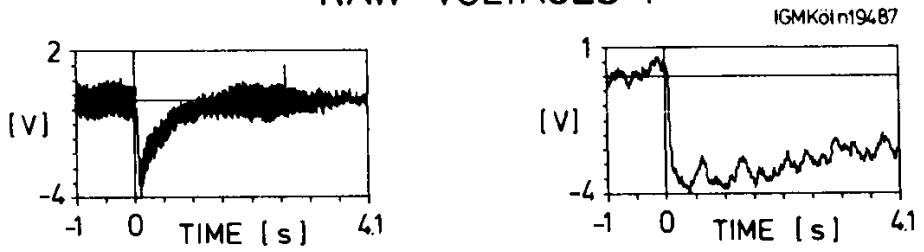
- Work was done in 1980s for BEB
- Only very limited information was released in obscure way
- Good well control but no detailed information was given.
- Results successful but unknown how.
- TODAY we know why!

Germany: partial basemap

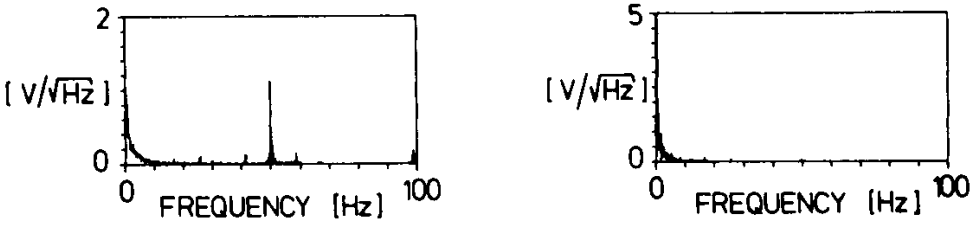


Germany: data

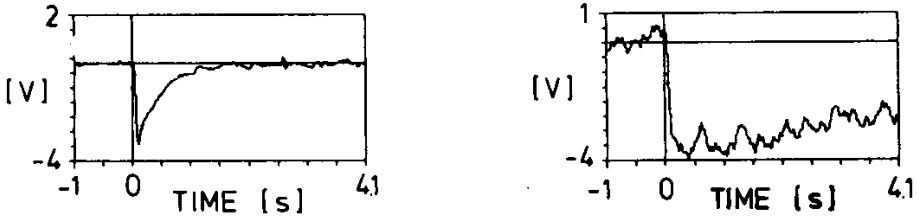
RAW VOLTAGES :



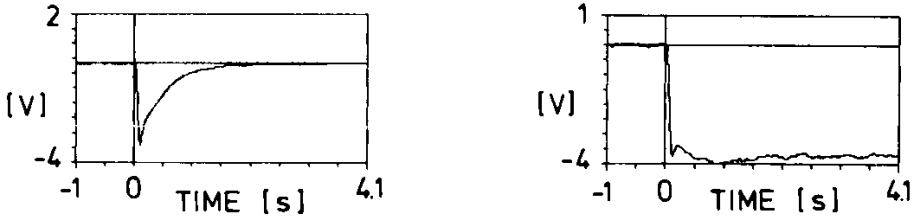
AMPLITUDE SPECTRA :



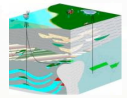
PROCESSED DATA :

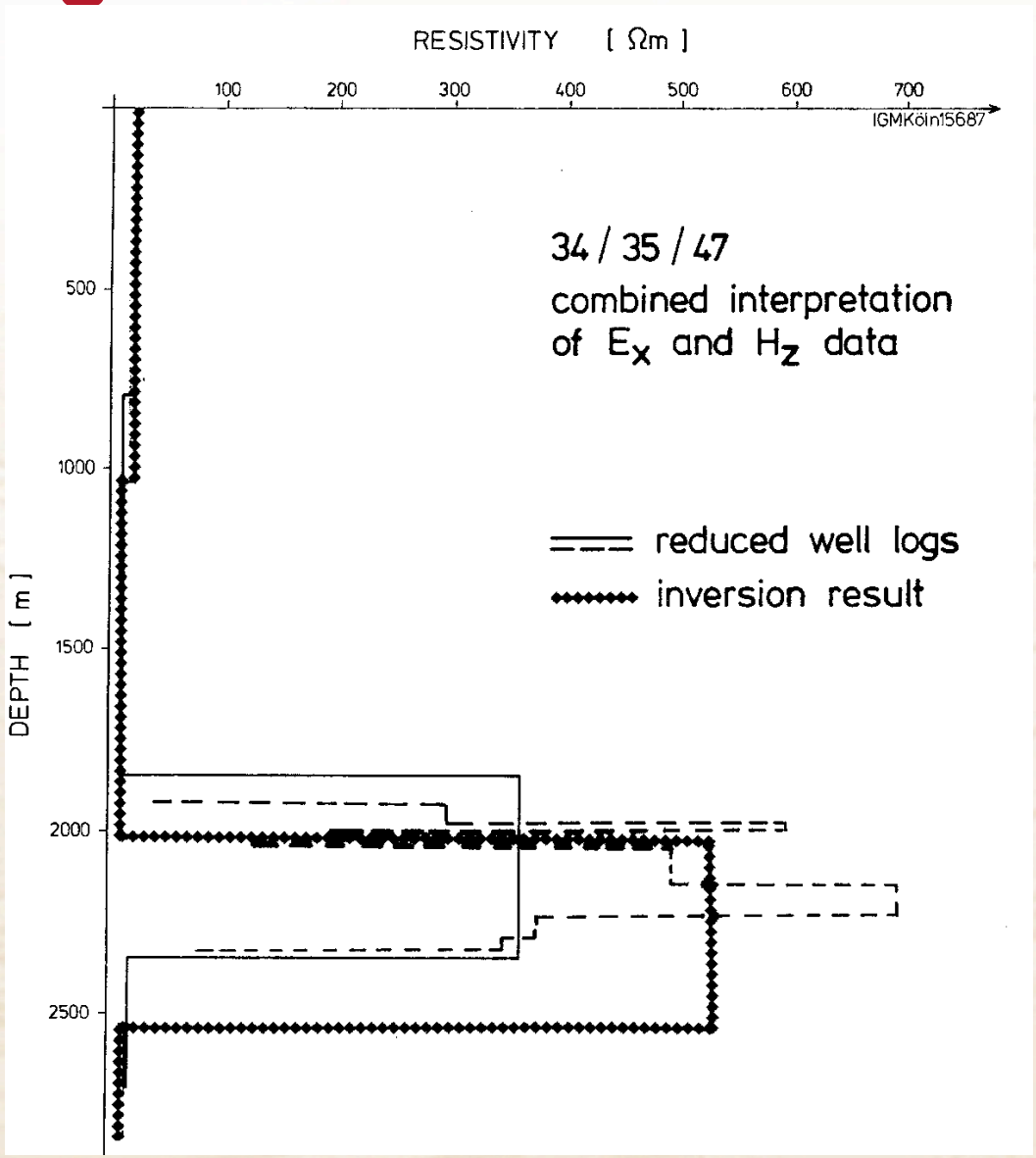


SELECTIVELY STACKED DATA :

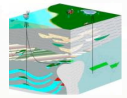


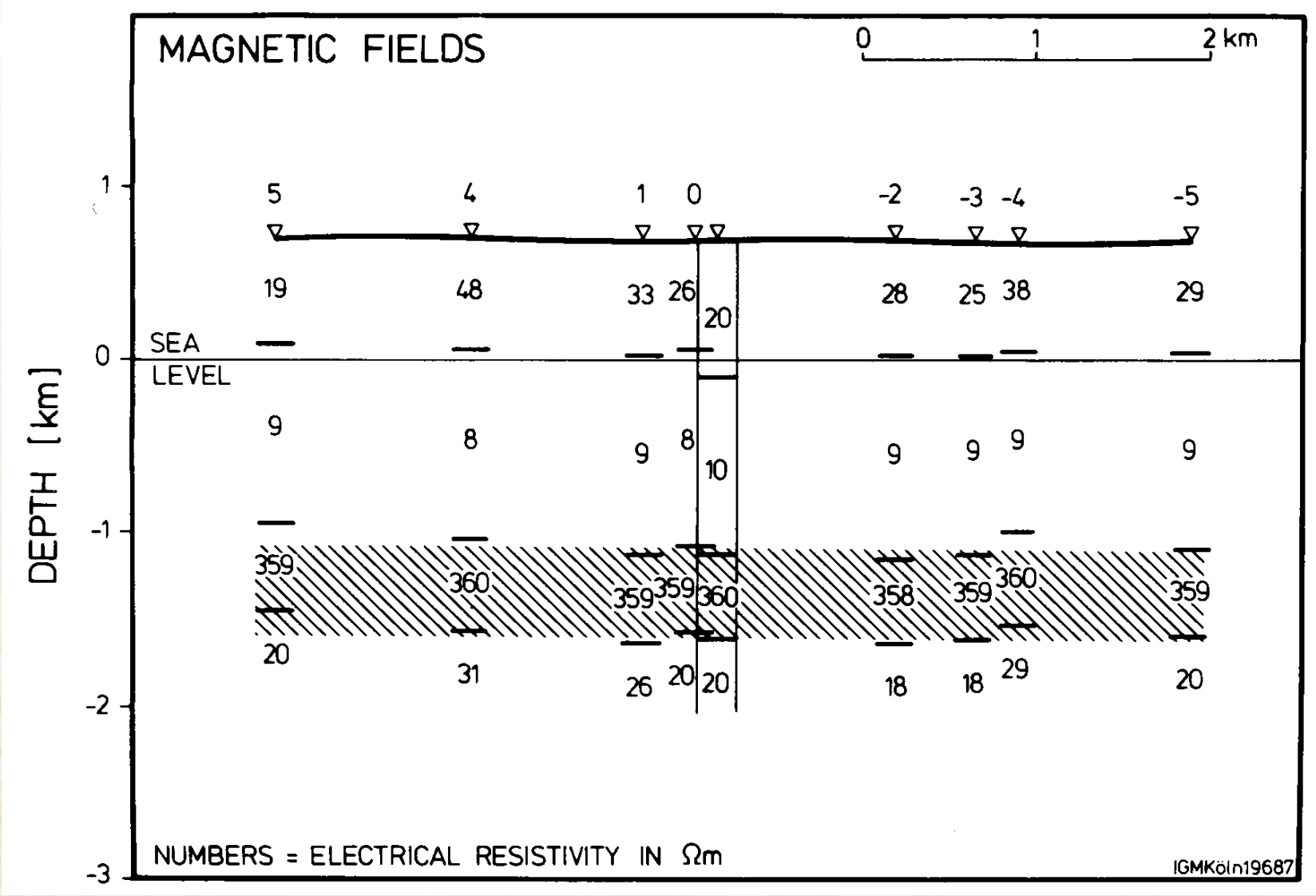
Germany: log & inversion result



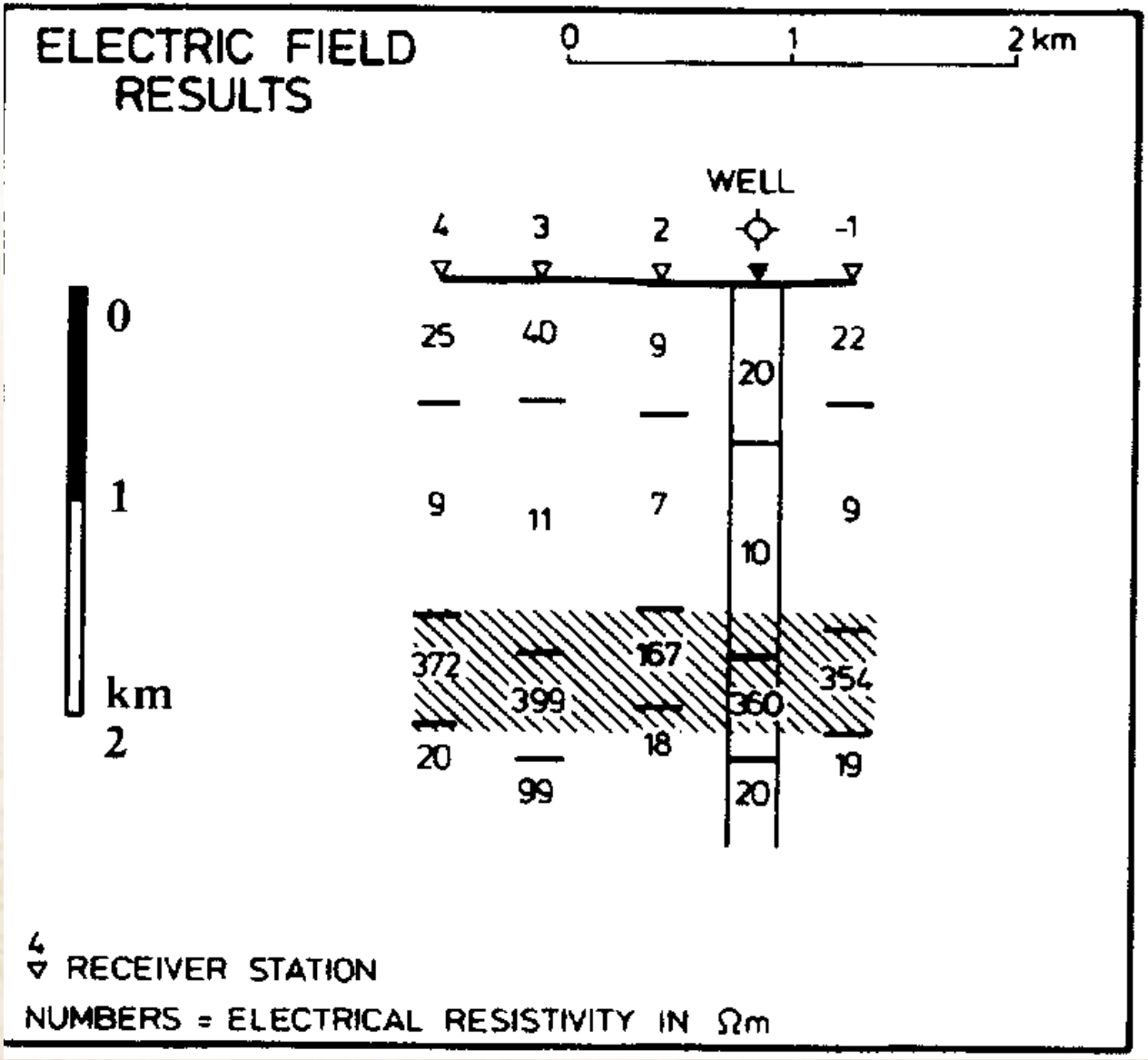


Germany: resistivity section H

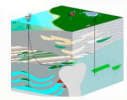


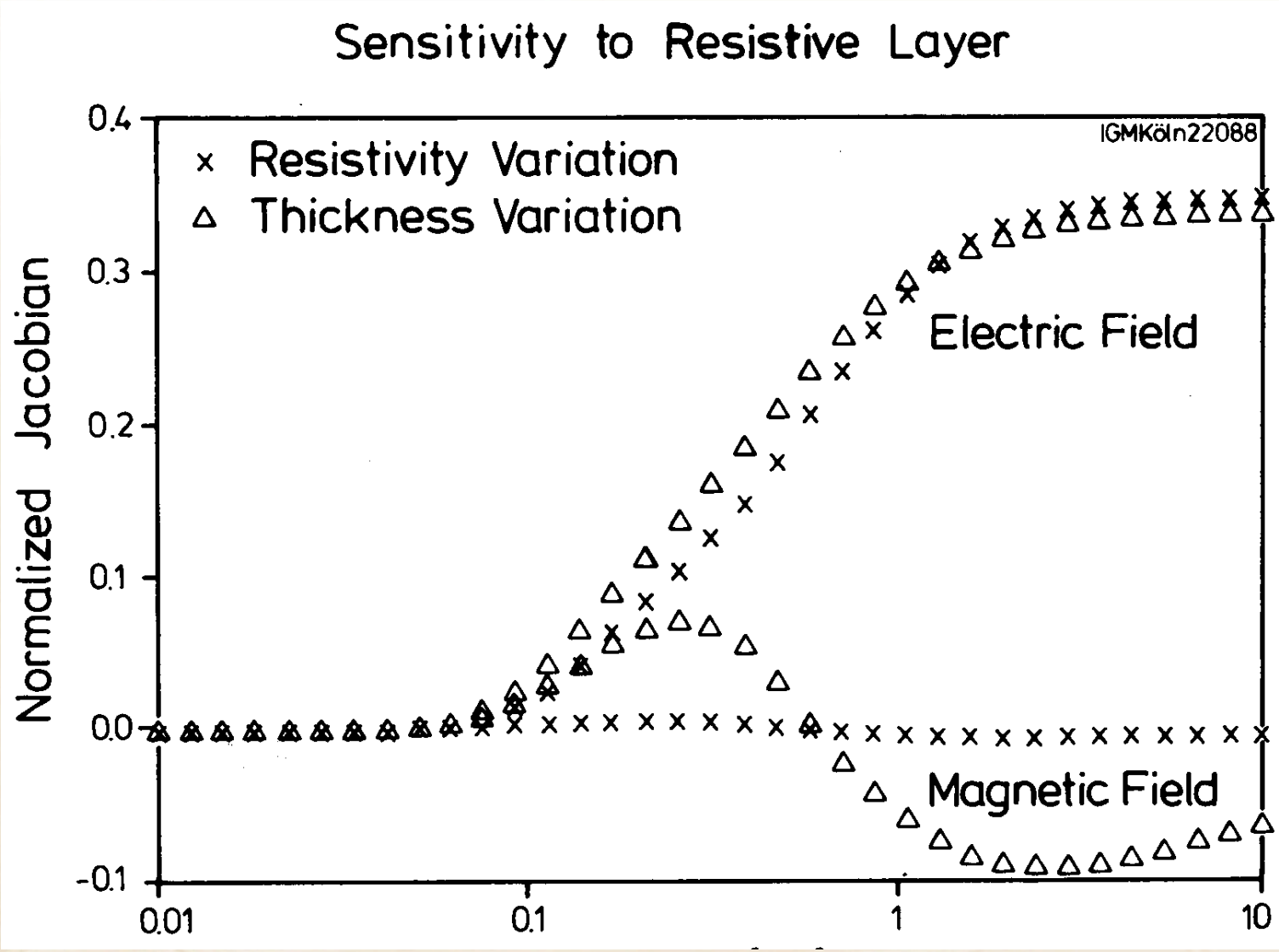


Germany: resistivity section E

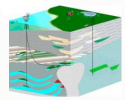


Germany: layer sensitivity





Agenda



- Historic background
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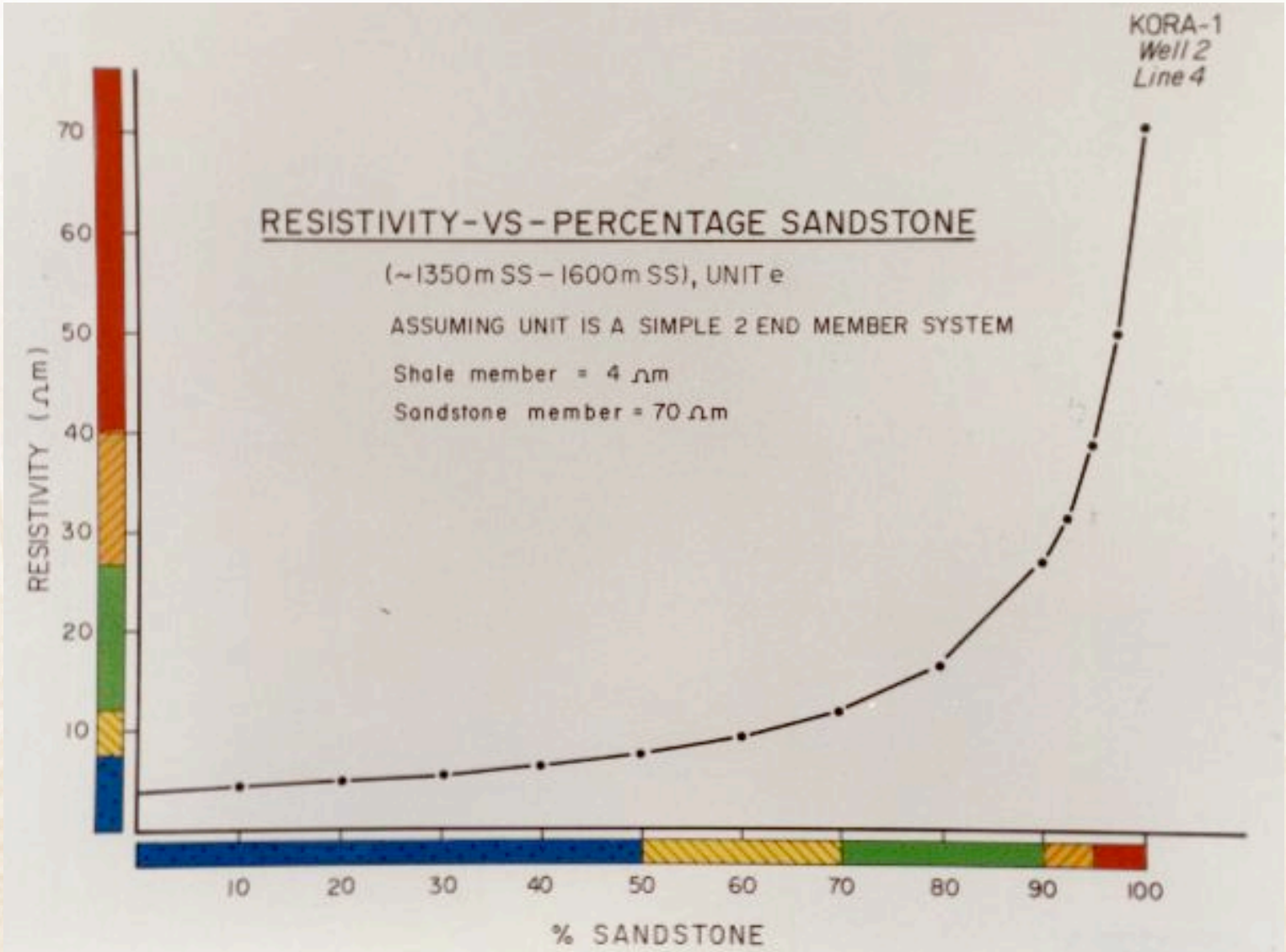
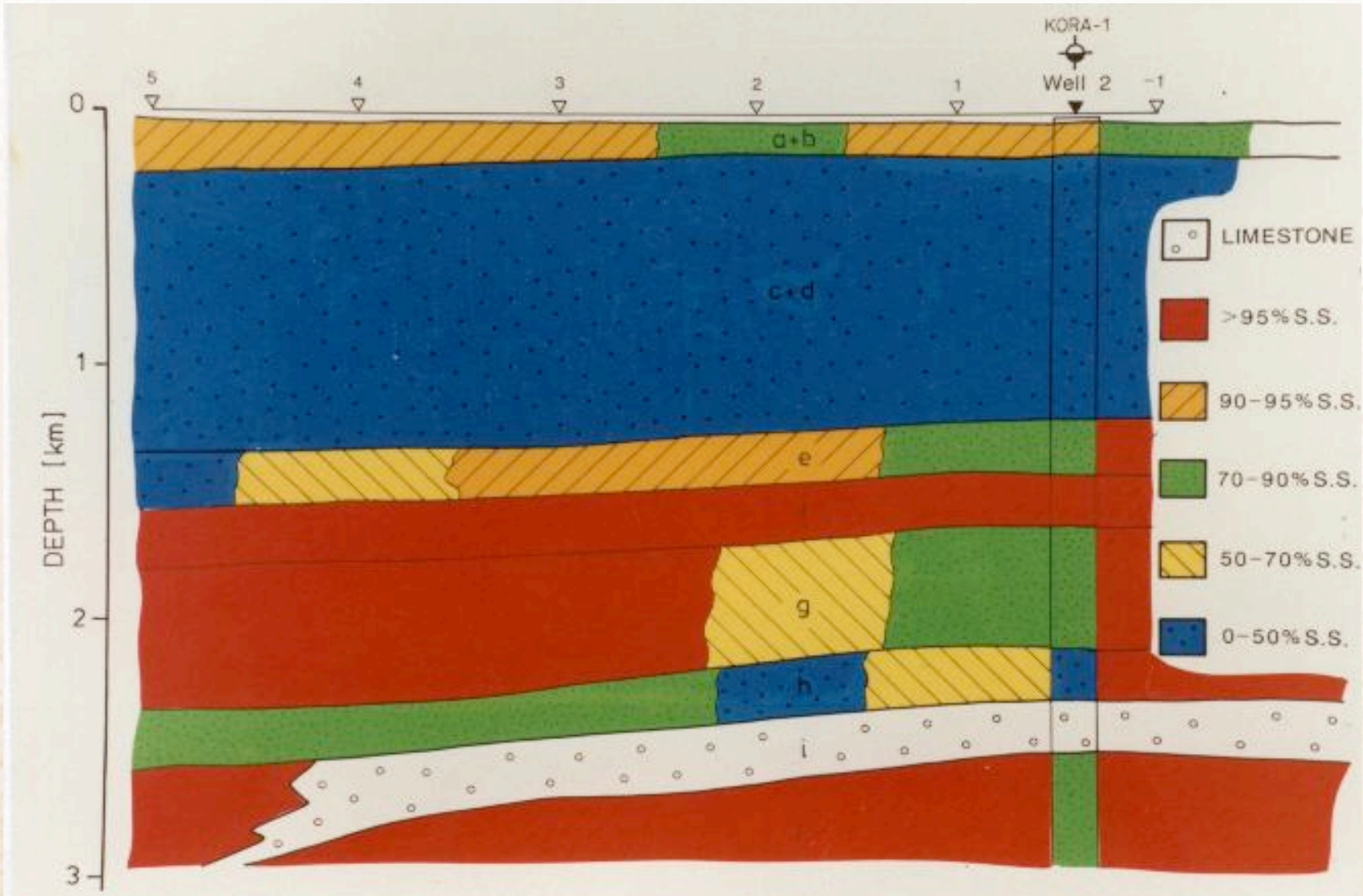
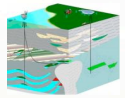
Canning Basin: ρ versus % SS



Canning Basin: interpreted res.. section



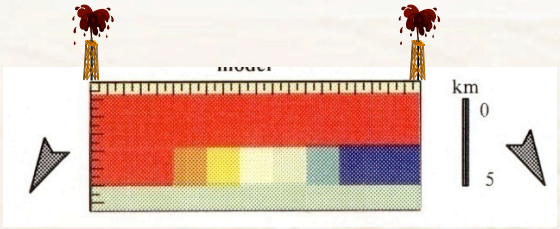
What do we need?



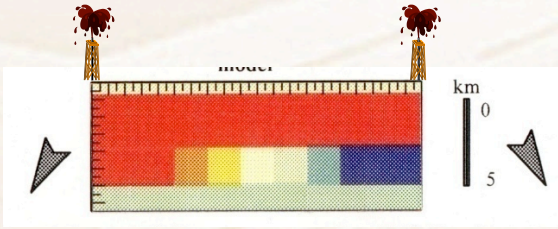
EM methods combined

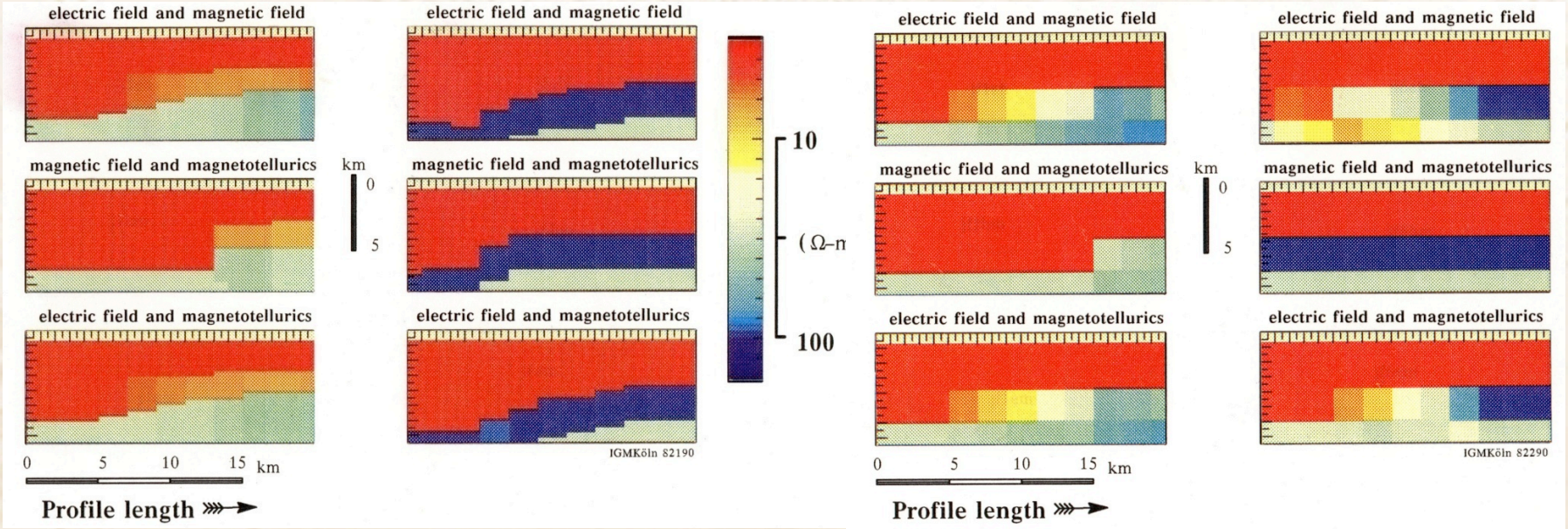
EM constraint by seismic

Start w/
left log

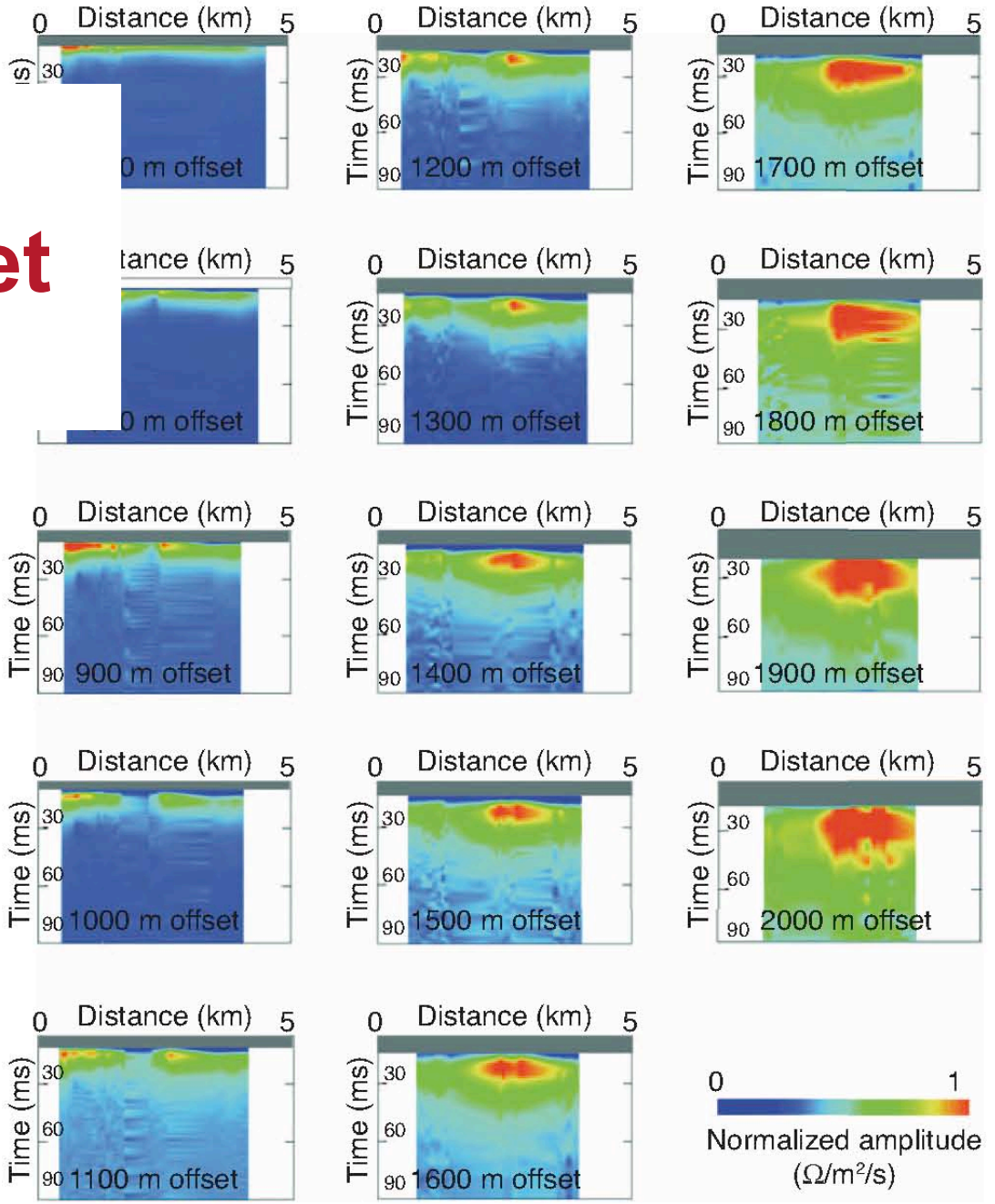


Start w/
right log



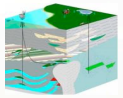


Images: Common Offset gathers

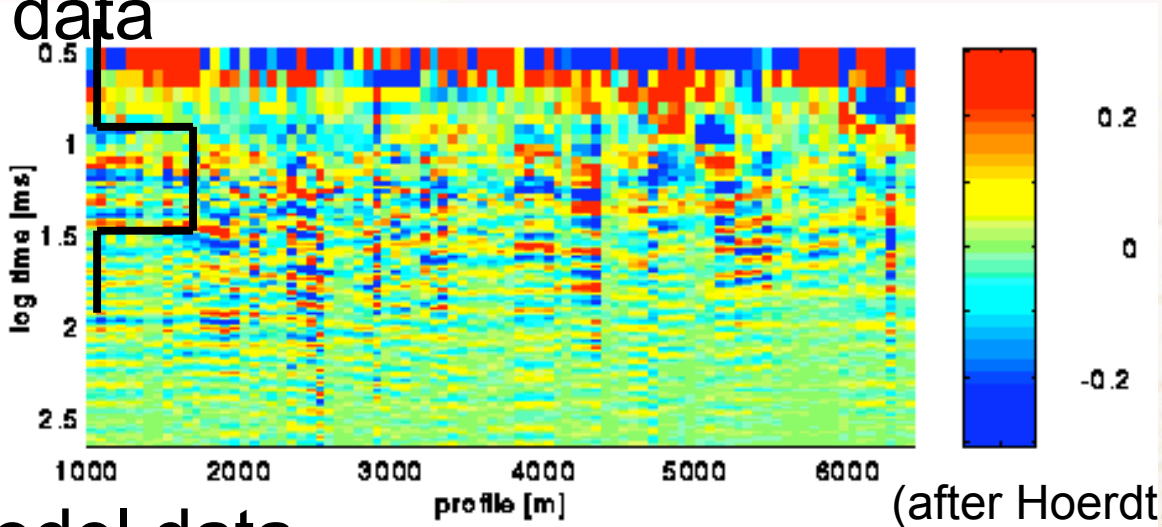


After Ziolkowsky et al. 2007

1995 field results

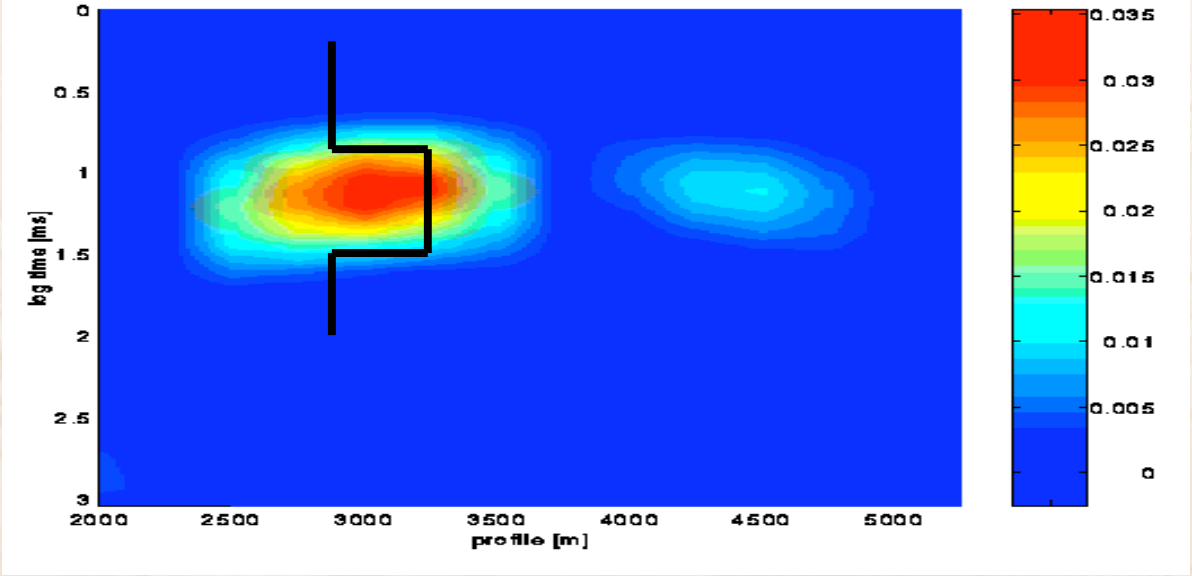


Filed data

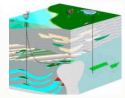


(after Hoerdt, pers. Comm.)

3D model data

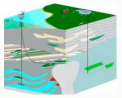


The arguments



- Hordt and Vozoff argued the time lapse results were not sufficient
- Ziolkowski & Hobbs were happy and started MTEM
- Today no serious follow up
- Why??? (borehole needed!)

Agenda



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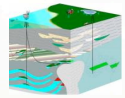
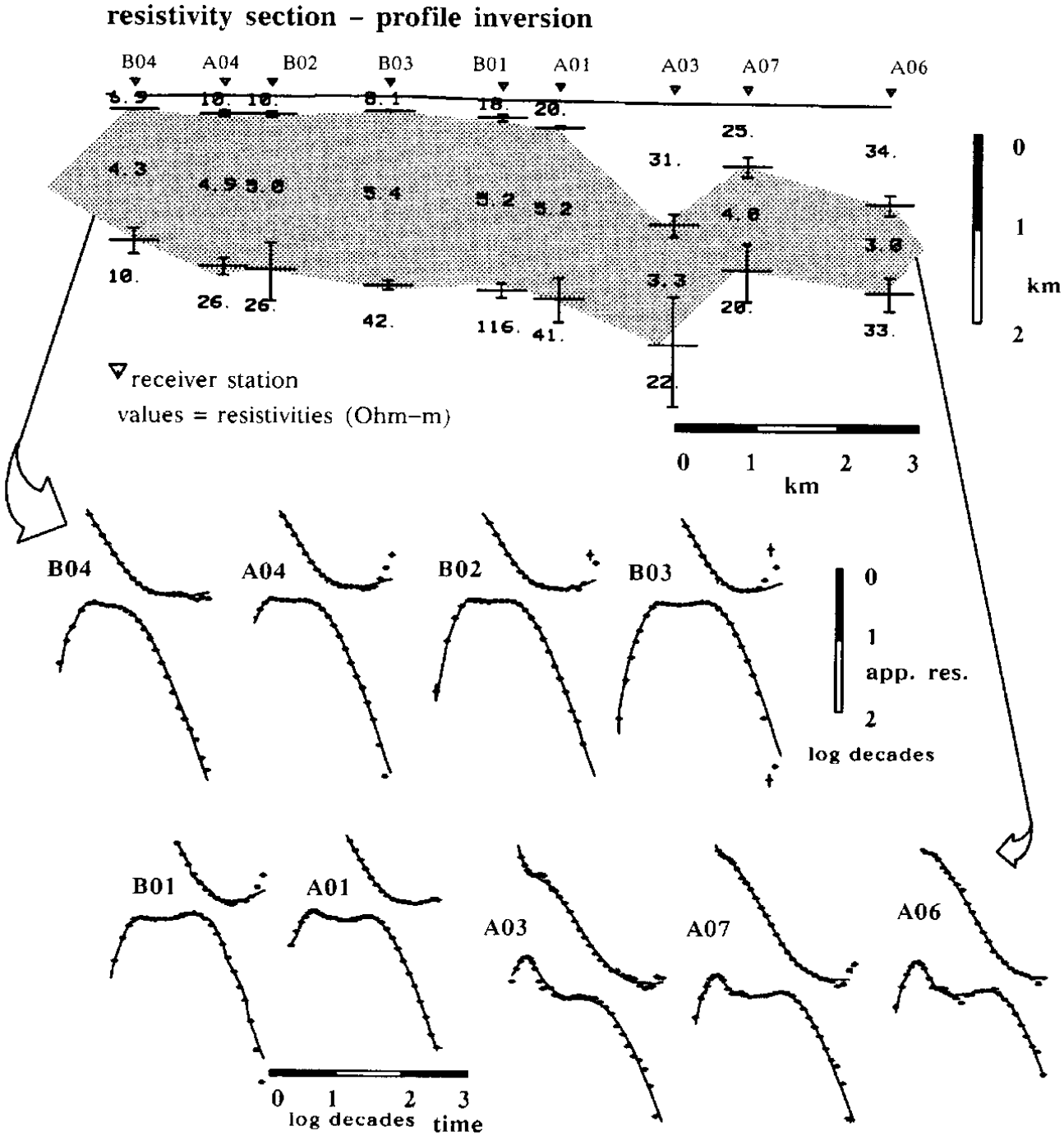
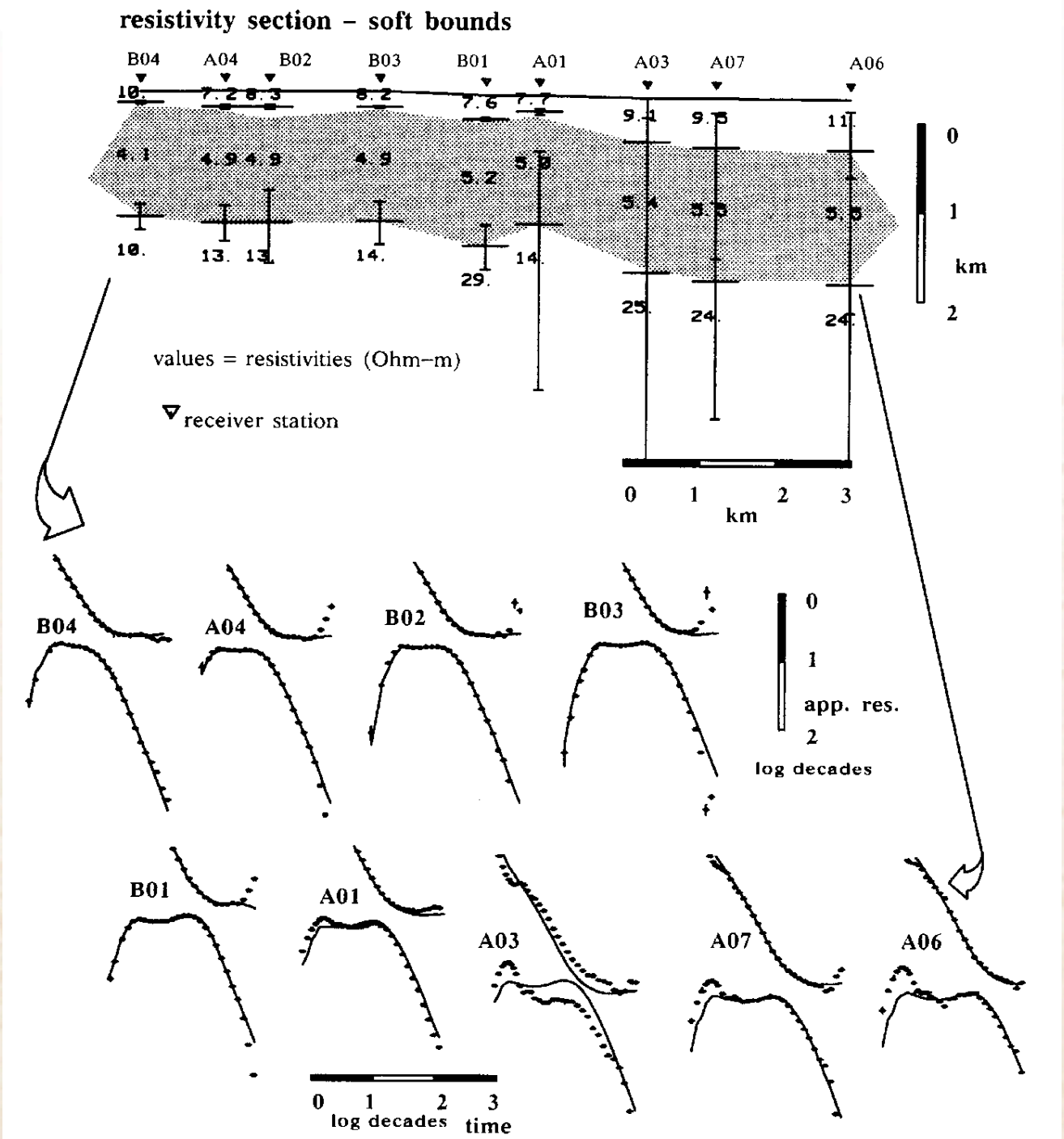
Vozoff inversion

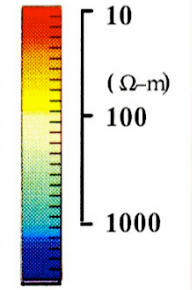


- 1955-1957: First inversion programs
  → 2010 SEG Reginald Fessenden Award
- Joint inversion 1970s
- 1980-1990: sideways and up/down; overlapping volume or not?
- MT-Lotem; E&H

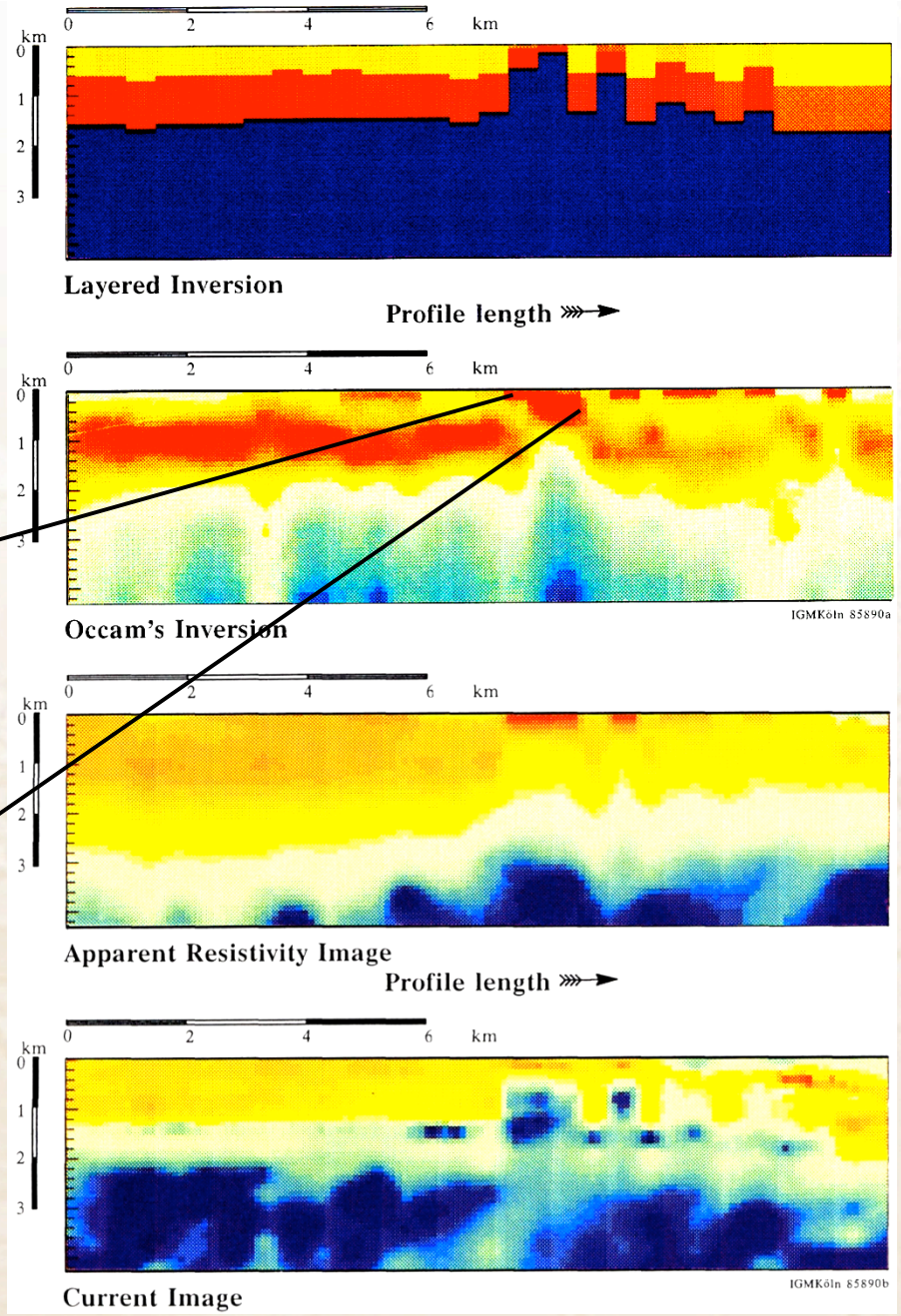

resistivity section – profile inversion
B04
A04
B02
B03
B01
A01
A03
A07
A06
receiver station
values = resistivities (Ohm-m)
0
1
km
2
0
1
2
3
km
B04
A04
B02
B03
0
1
app. res.
2
log decades
B01
A01
A03
A07
A06
0
1
2
3
log decades
time


resistivity section – soft bounds
B04
A04
B02
B03
B01
A01
A03
A07
A06
values = resistivities (Ohm-m)
receiver station
0
1
km
2
0
1
2
3
km
B04
A04
B02
B03
0
1
app. res.
2
log decades
B01
A01
A03
A07
A06
0
1
2
3
log decades
time

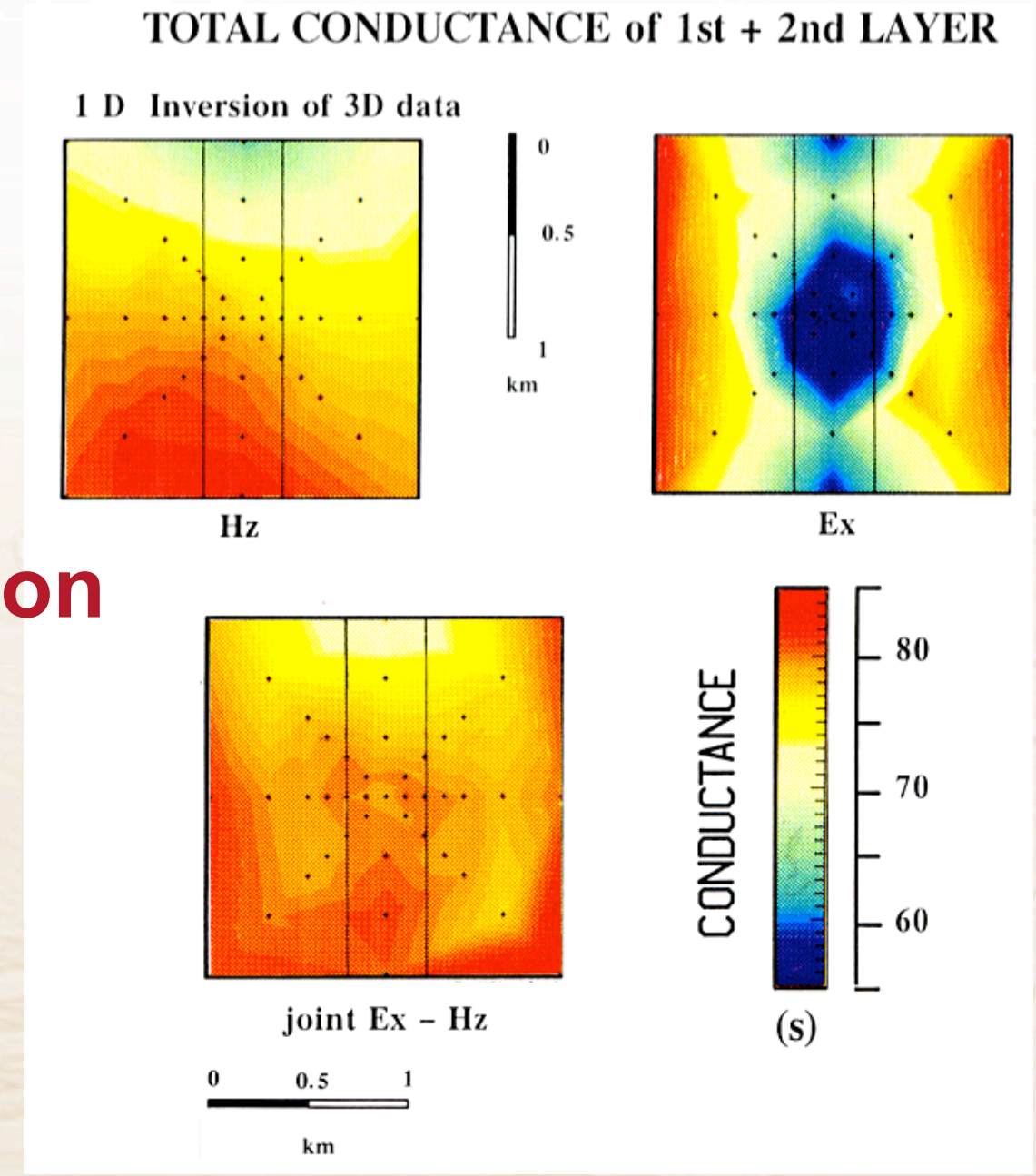
Data images



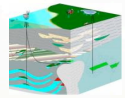
Surface outcrop:



3D location test

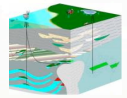


Agenda



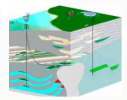
- Historic background
- Resolving resistive layers
- Mapping porosities
- Inversion up and down
- Where do we go from here?

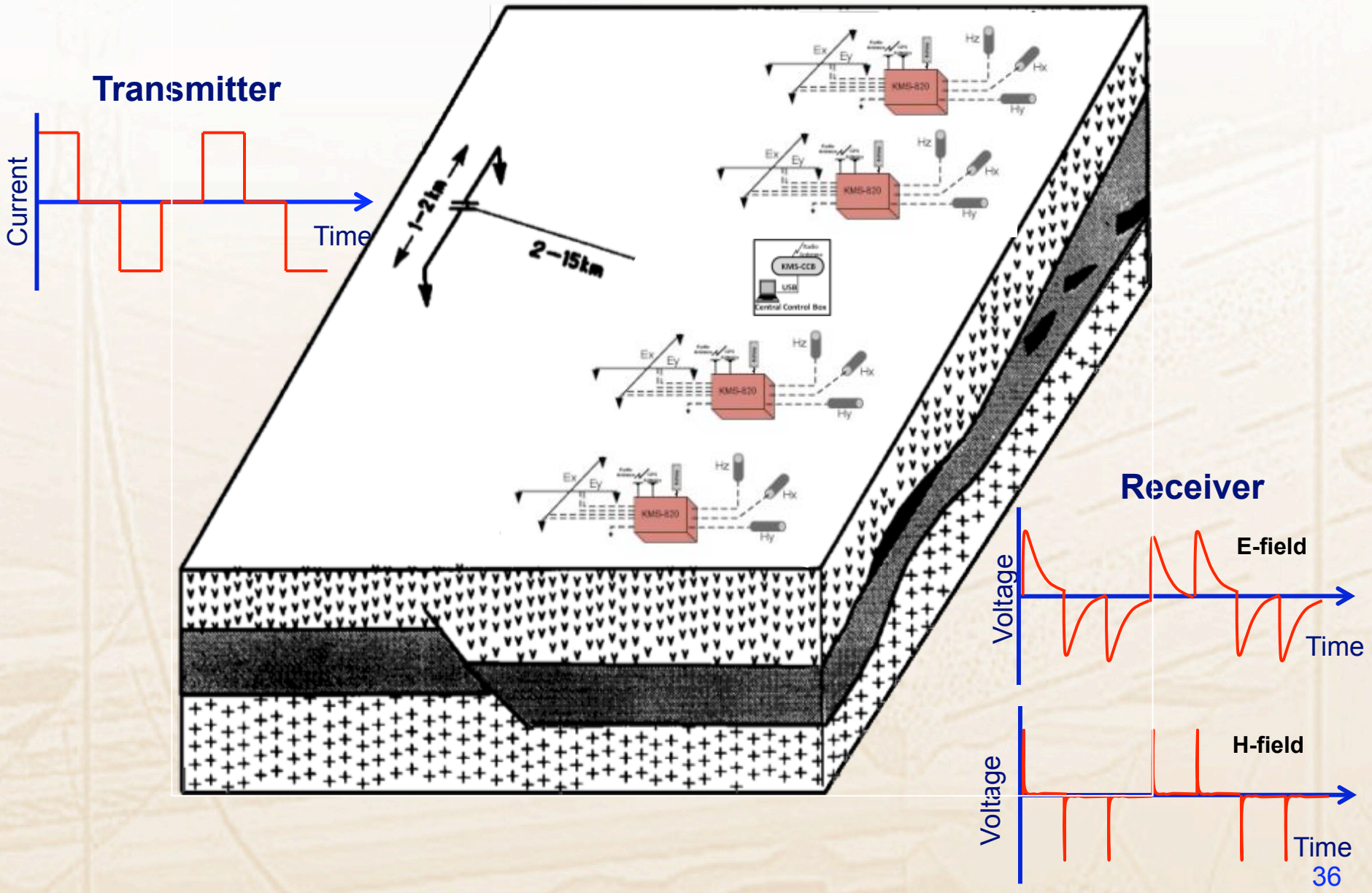
The Future: technical view



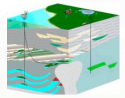
- EM must reduce unit cost by 10.
  - Not MT or Lotem BUT MT/CSEM
- Resolution/channel count must increase (10).
- Driver must be the seismic 3D cube.

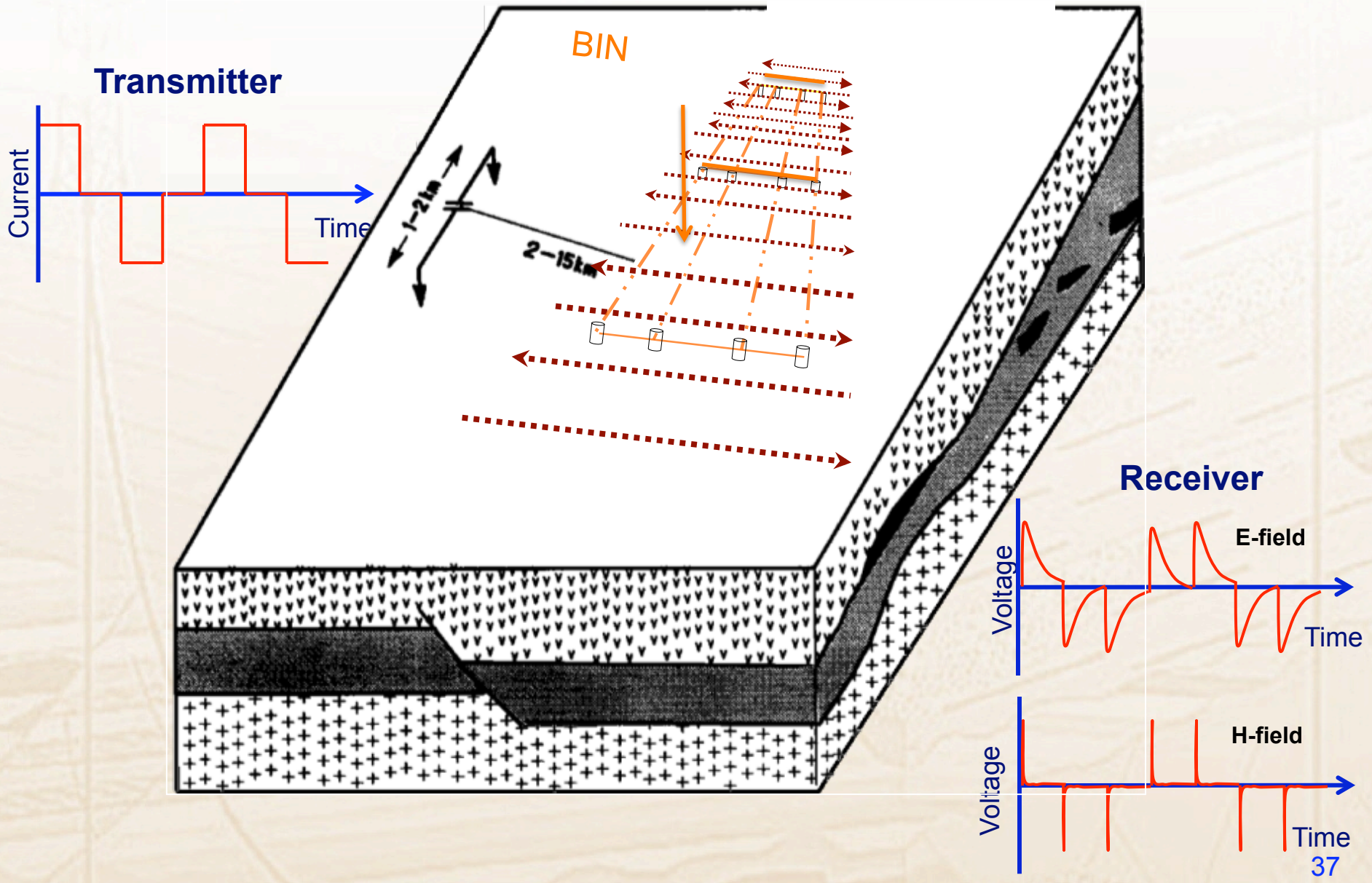
Cost reduction: EM-all-in-ONE



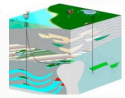


3D setup



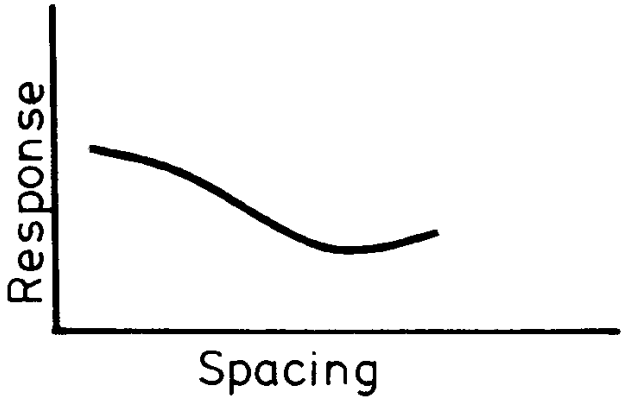

Transmitter
Current
Time
BIN
1–2km
2–15km
Receiver
E-field
Voltage
Time
H-field
Voltage
Time

Sounding parameters

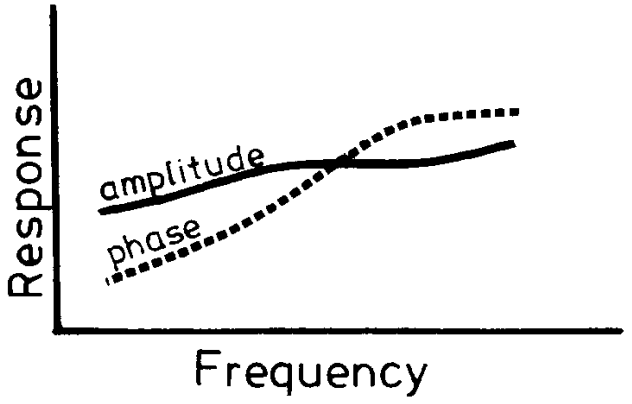


- 2 directions
- tensor measurements
- Large f band → depth

GEOMETRIC



FREQUENCY DOMAIN



Time domain measurement mode

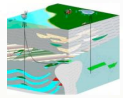
I told you so

Additional:
Distance vs. time of diffusion

more later

Applicable to:
TEM
time domain induced polarization

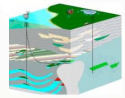
Sensors → lower cost



Fluxgates – 3 components

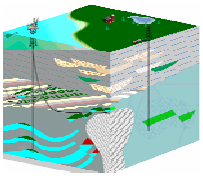
Induction coils – T & F domain

Path forward



- Make EM and integral part to seismic.
- Reduce hardware cost (first 1/3, then 1/10).
- Processing & interpretation seismic-style.
- Use key geosciences (3D inversion) to tie to value solution (operating decisions).

- This presentation will be at www.kmstechnologies.com >> technology library



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