3D SEISMIC: THE GEOLOGICAL 'HUBBLE'

Joe Cartwright

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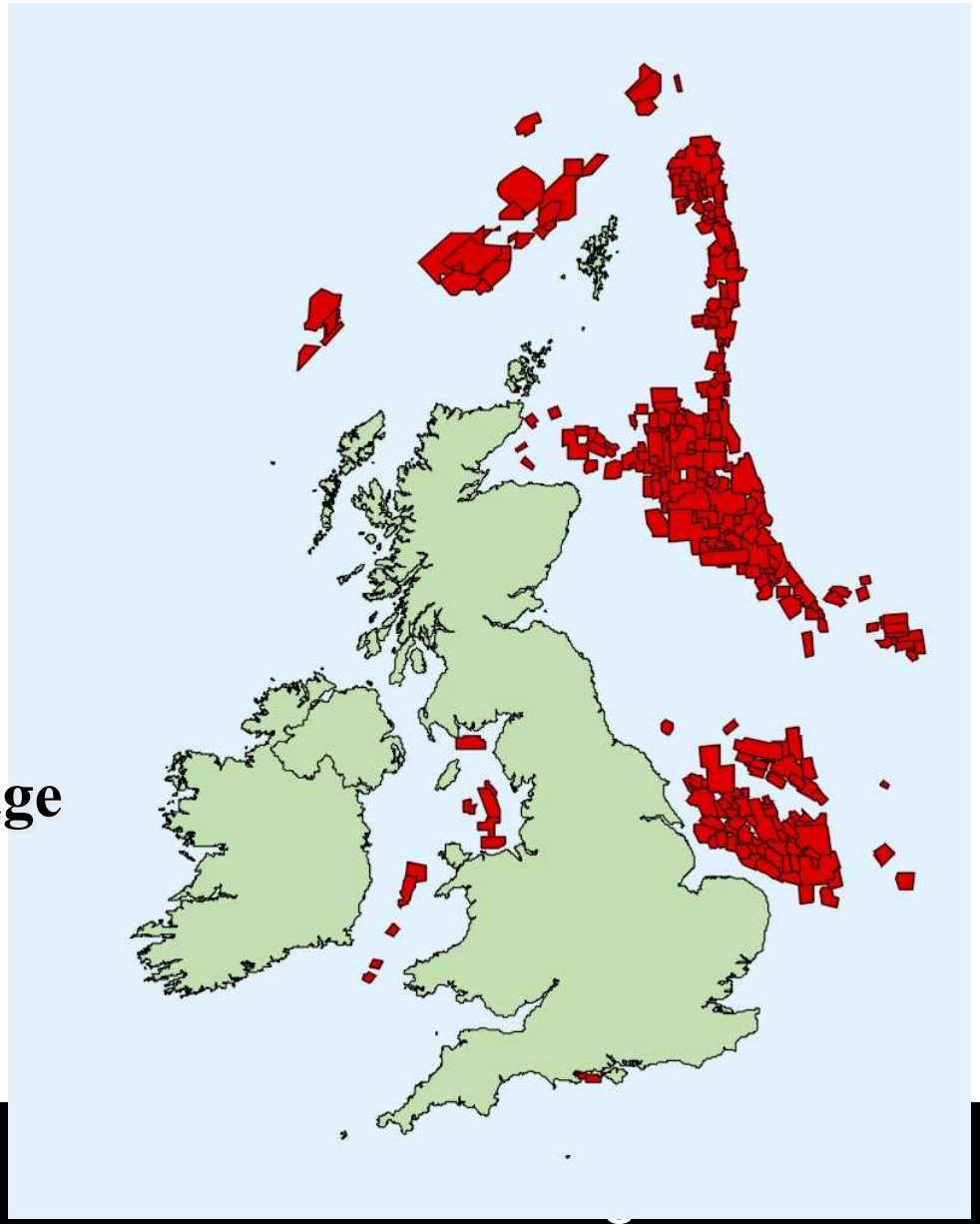
2001 UKCS 3D coverage: 137,688km2



Highest % coverage by surface area

AIM OF TALK

Explore the potential for 3D Seismic as a tool for geoscience research

Show what PhD research can achieve:

Aidan Joy, Chris Mansfield, Edwin Tervoort, Dustin Lister, Stephen Molyneux, Renaud Bouroullec, Jon Clemson, James Clark, Andrew Robinson, Dorthe Hansen, Jens Hansen, Valente Paramo, James Trude, Simon Shoulders, Jose Martinez, Sulaiman Al-Bassam, Thomas Melgaard, Mike Hohbein, Claudia Bertoni, Catherine Baudon and Mairi Nelson.

BP, Shell, Hydro, Statoil, Schlumberger, Veritas, PGS, NERC, Total, Hess, ExxonMobil BGgroup, ConocoPhilips, IMP, Danish Academy, Royal Society.

Themes

Seismic Palaeoceanography

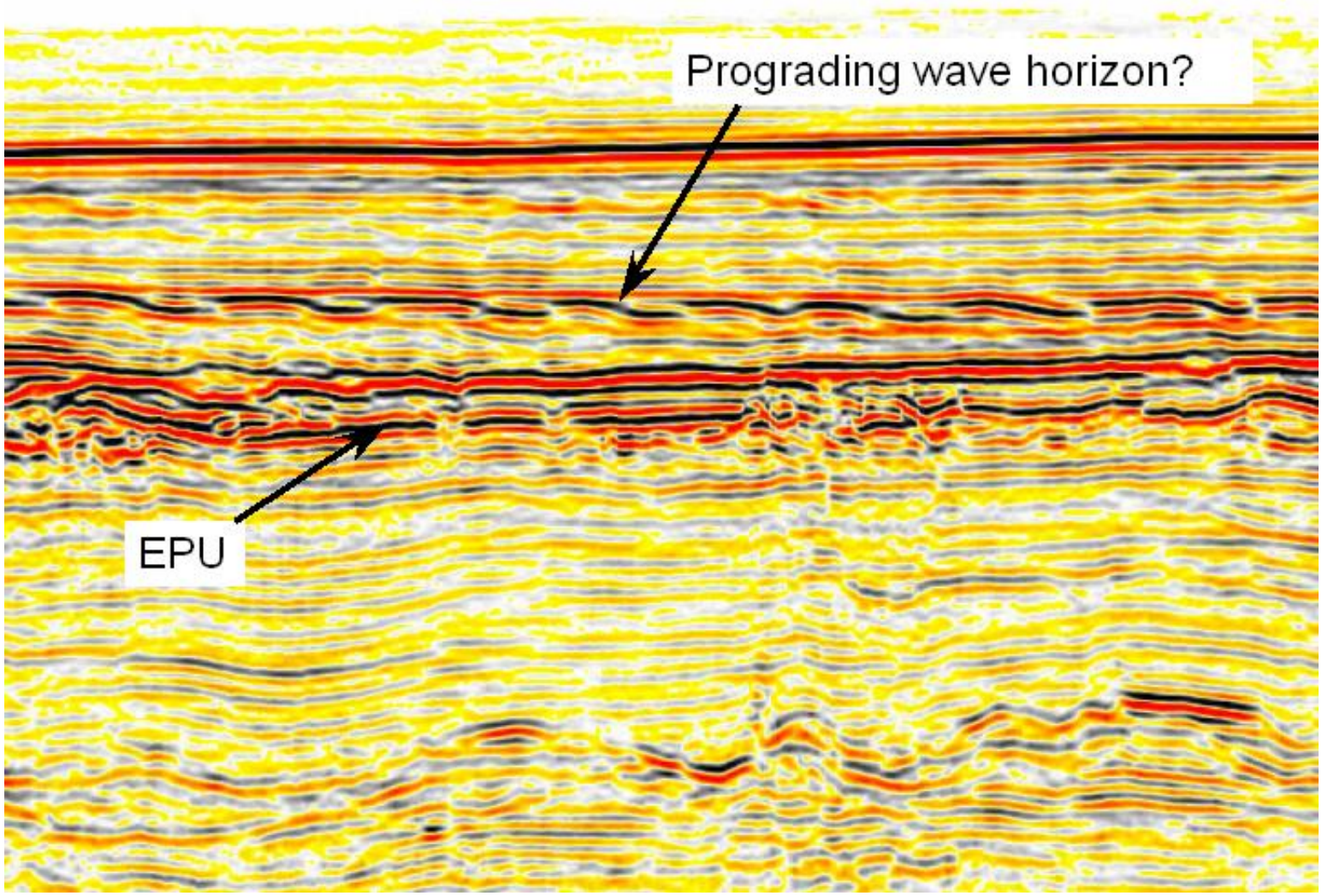
Crustal Magma Transport

Basin Hydrodynamics

Odds and Ends

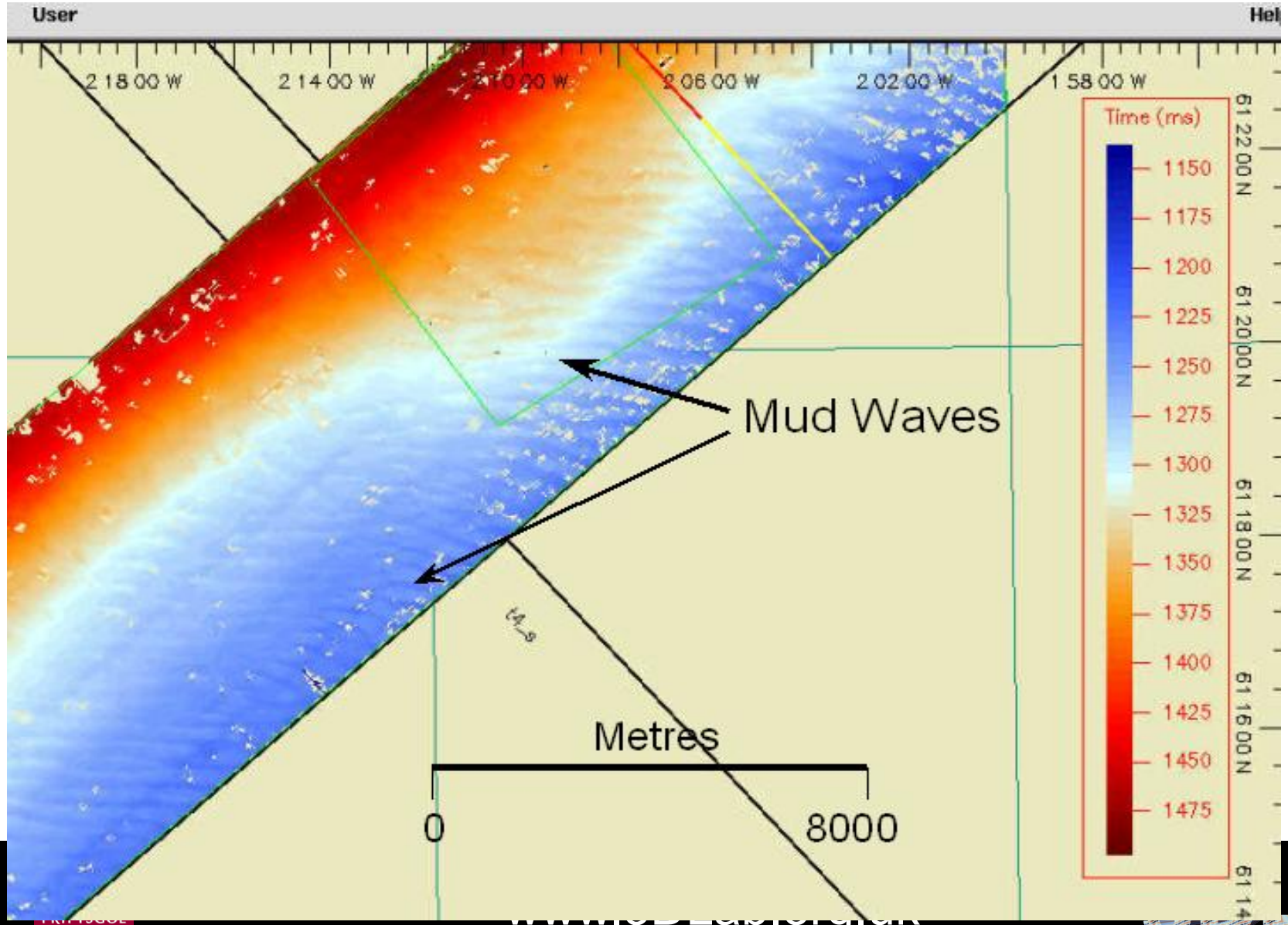
Geometry and kinematics…….

Hohbein et al. 2004



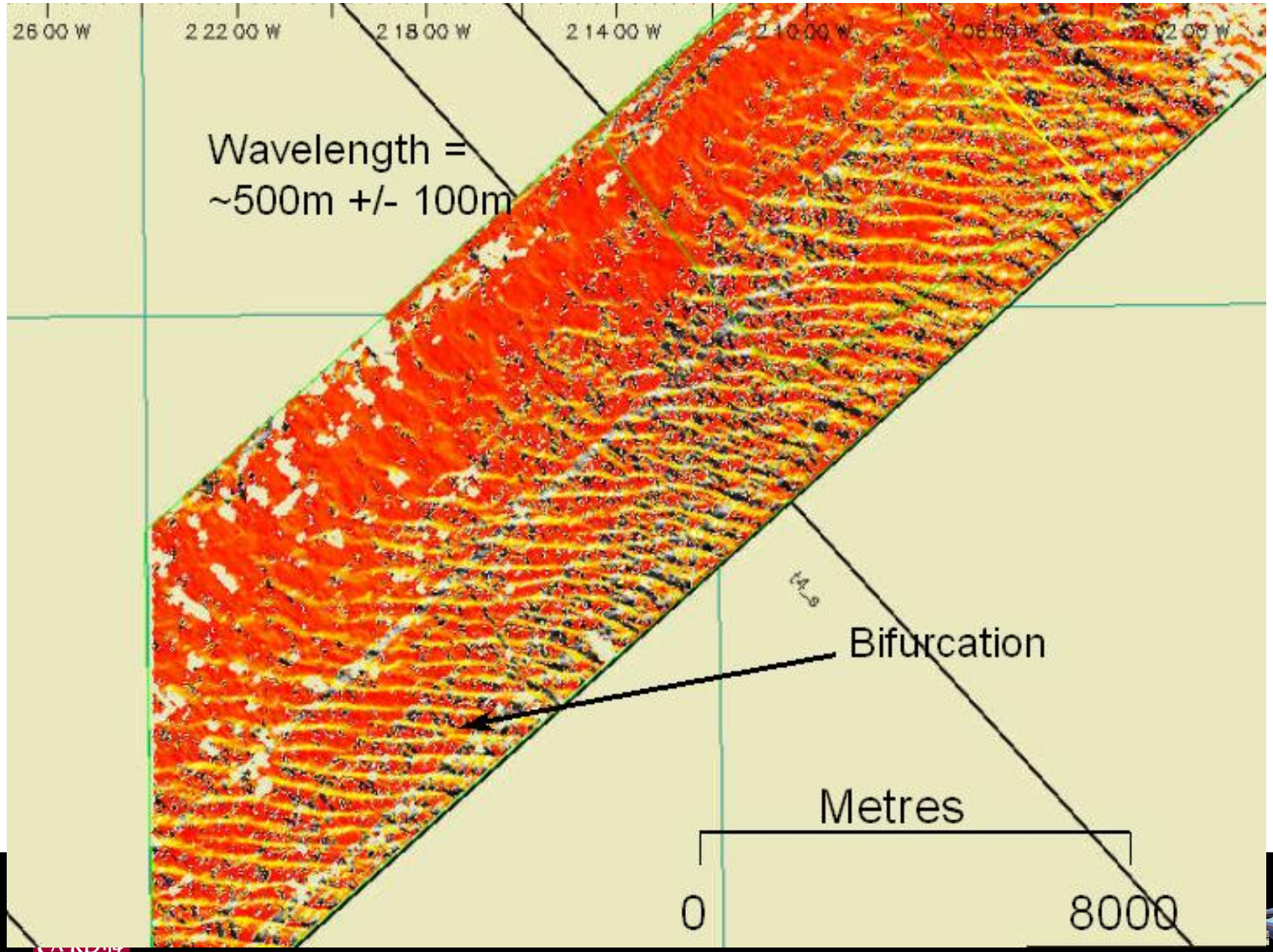
Hohbein et al. 2004

TIME MAP – t4w

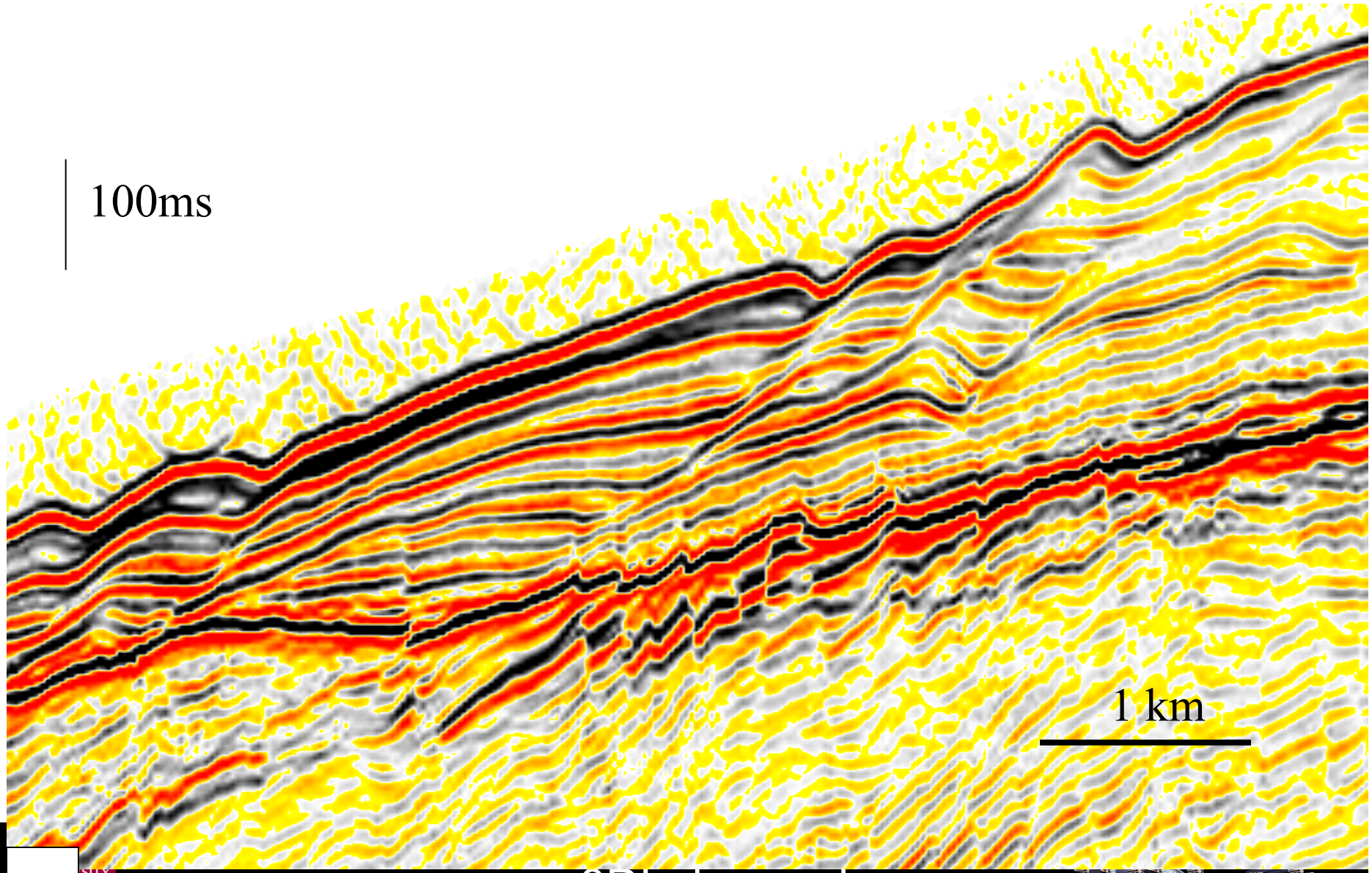


DIP AND AZIMUTH MAP

Hohbein et al. 2004

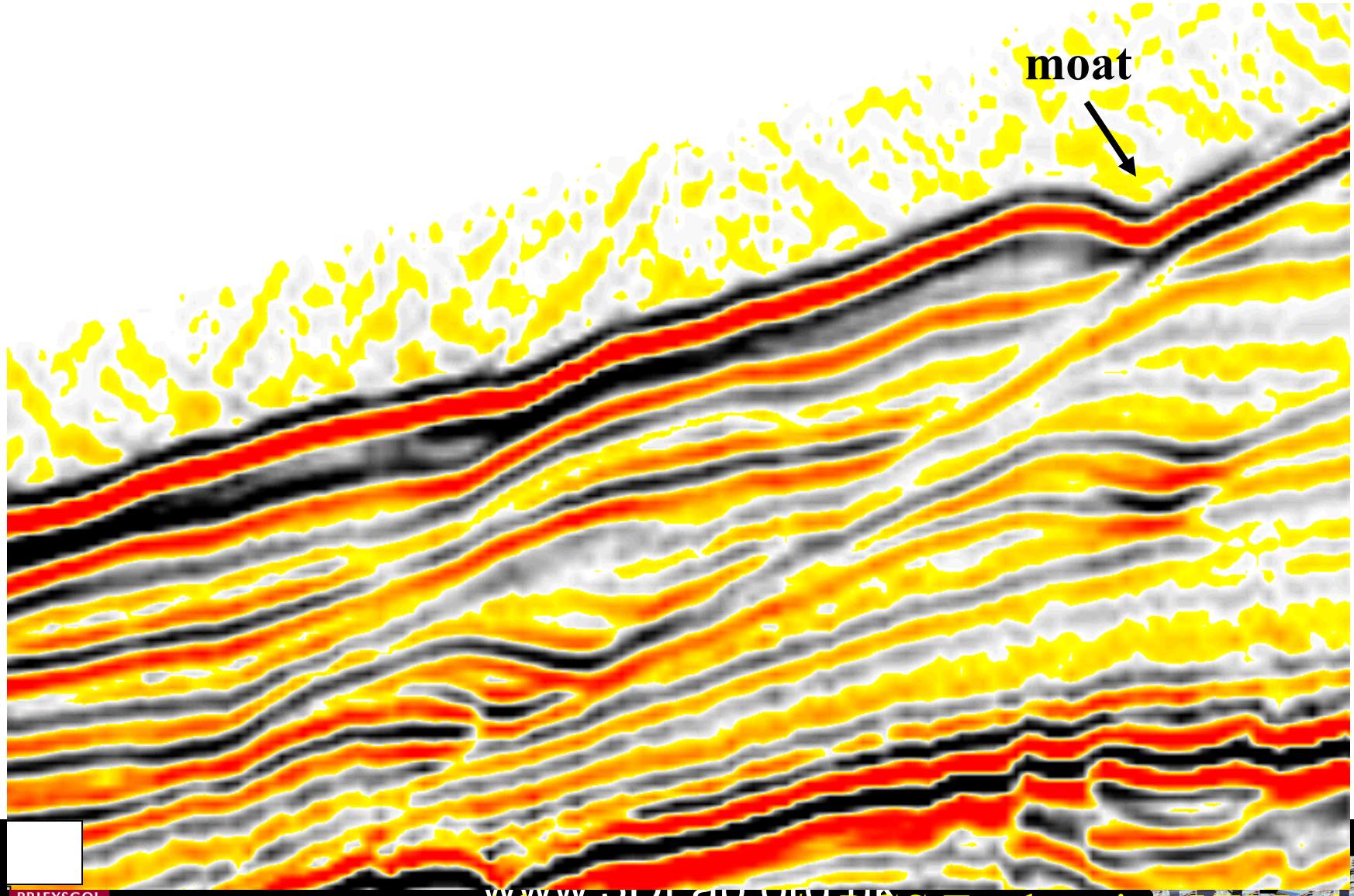


Knutz et al. 2004



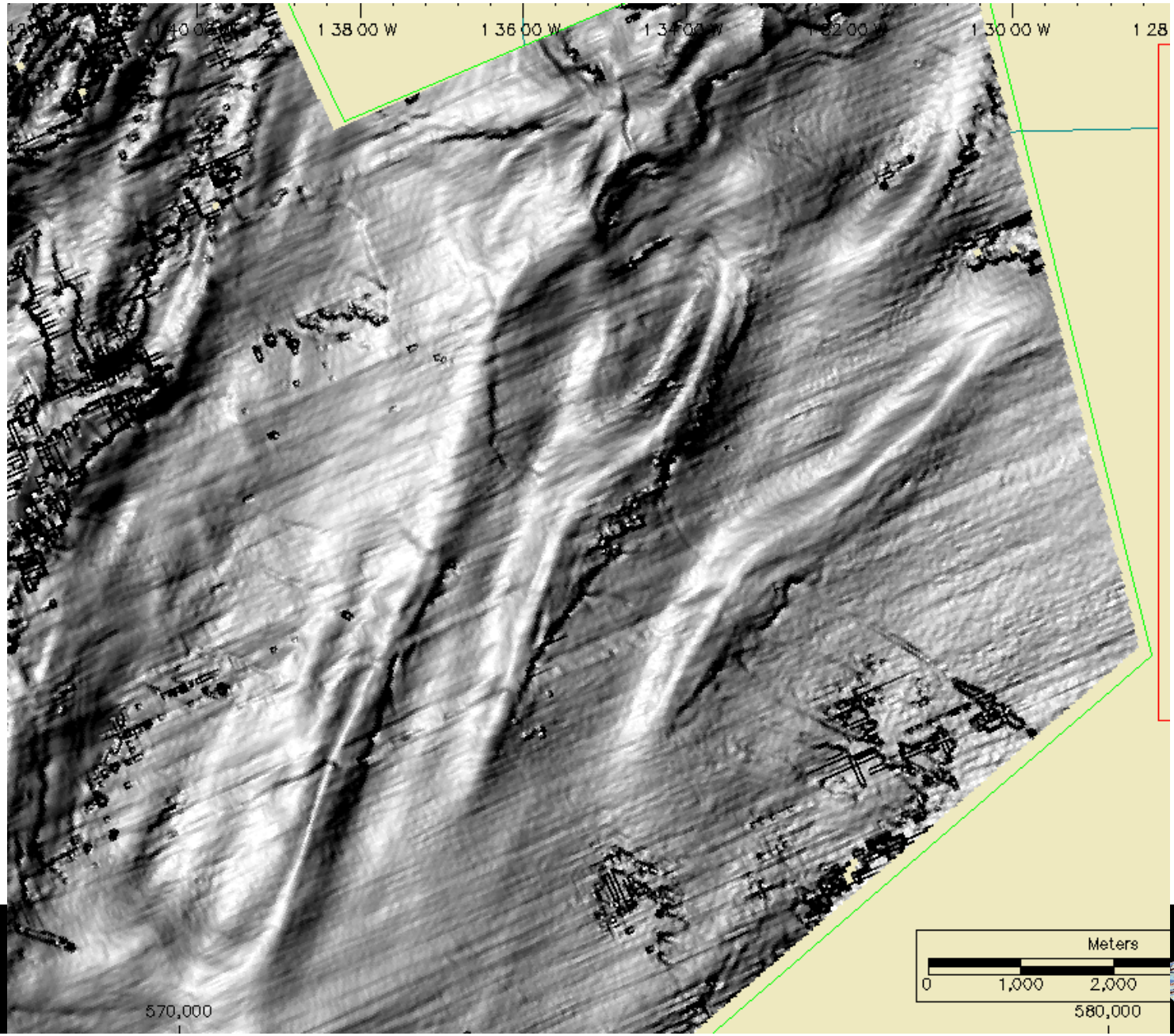
Knutz et al. 2004

Upslope migrating 'sediment waves'



Dipmap showing moat architecture

Knutz et al. 2004

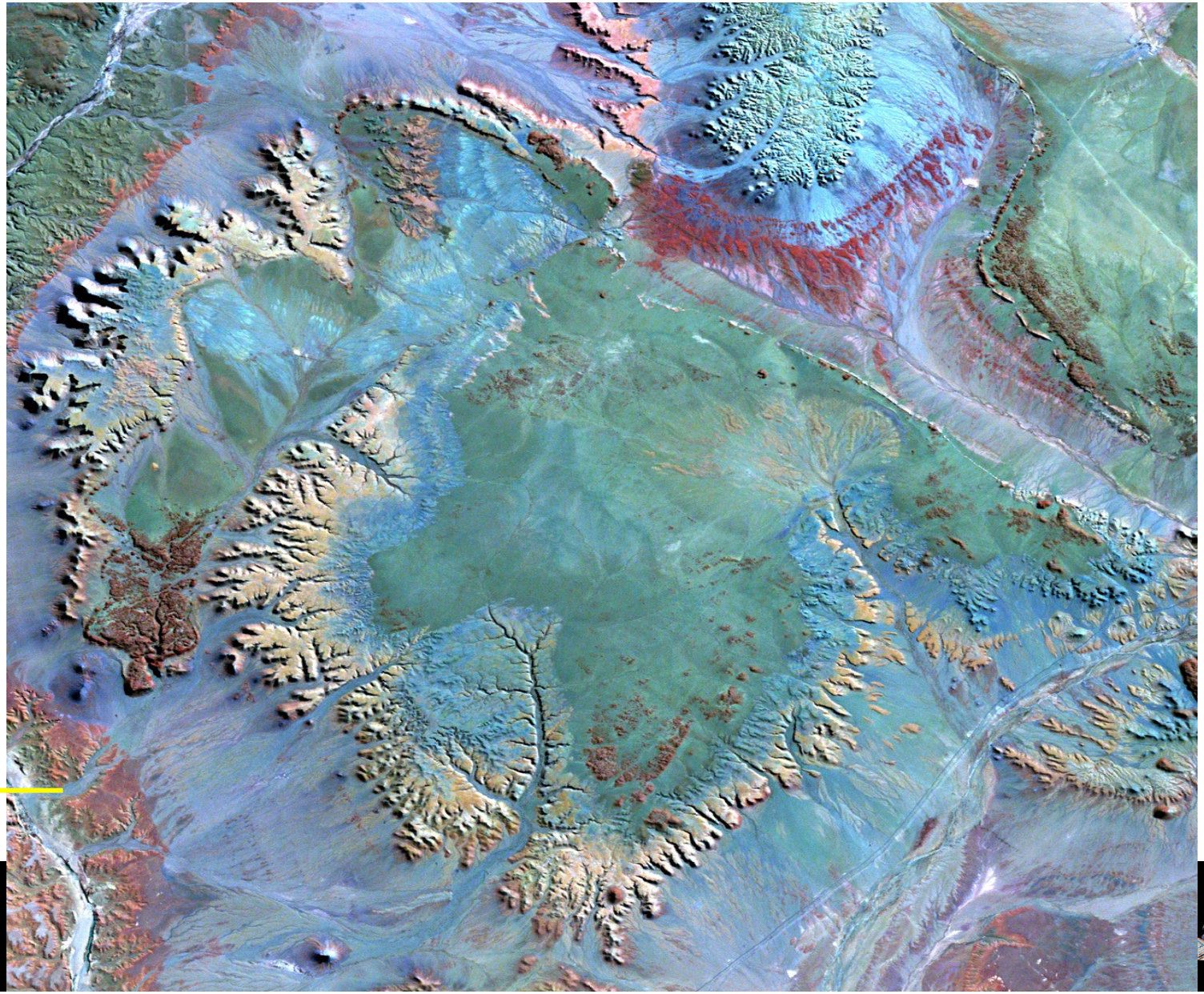


Igneous systems

3D geometry and emplacement mechanics of igneous intrusions

Magma transport in sedimentary basins

Saucer-shaped sills: Namibia



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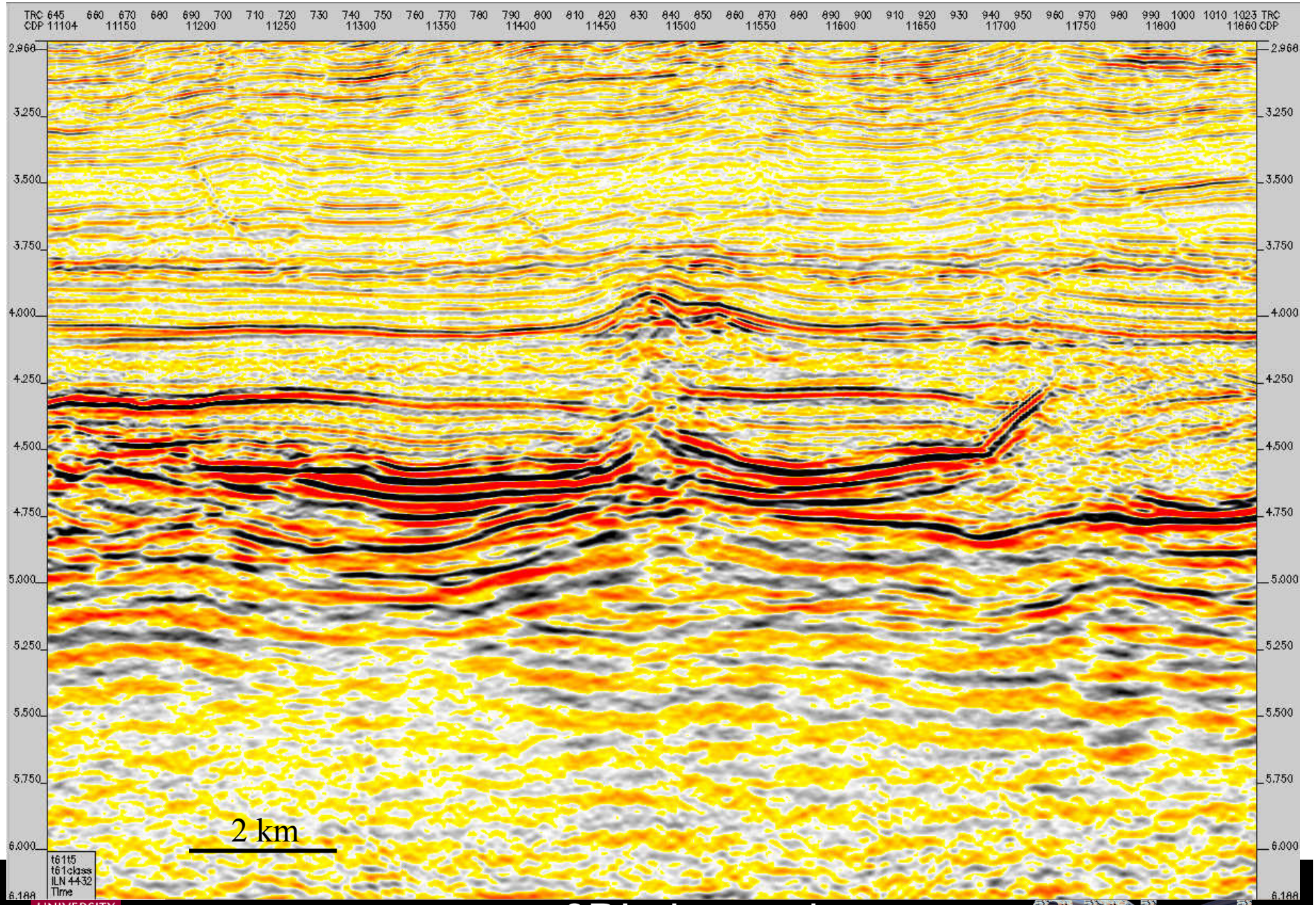
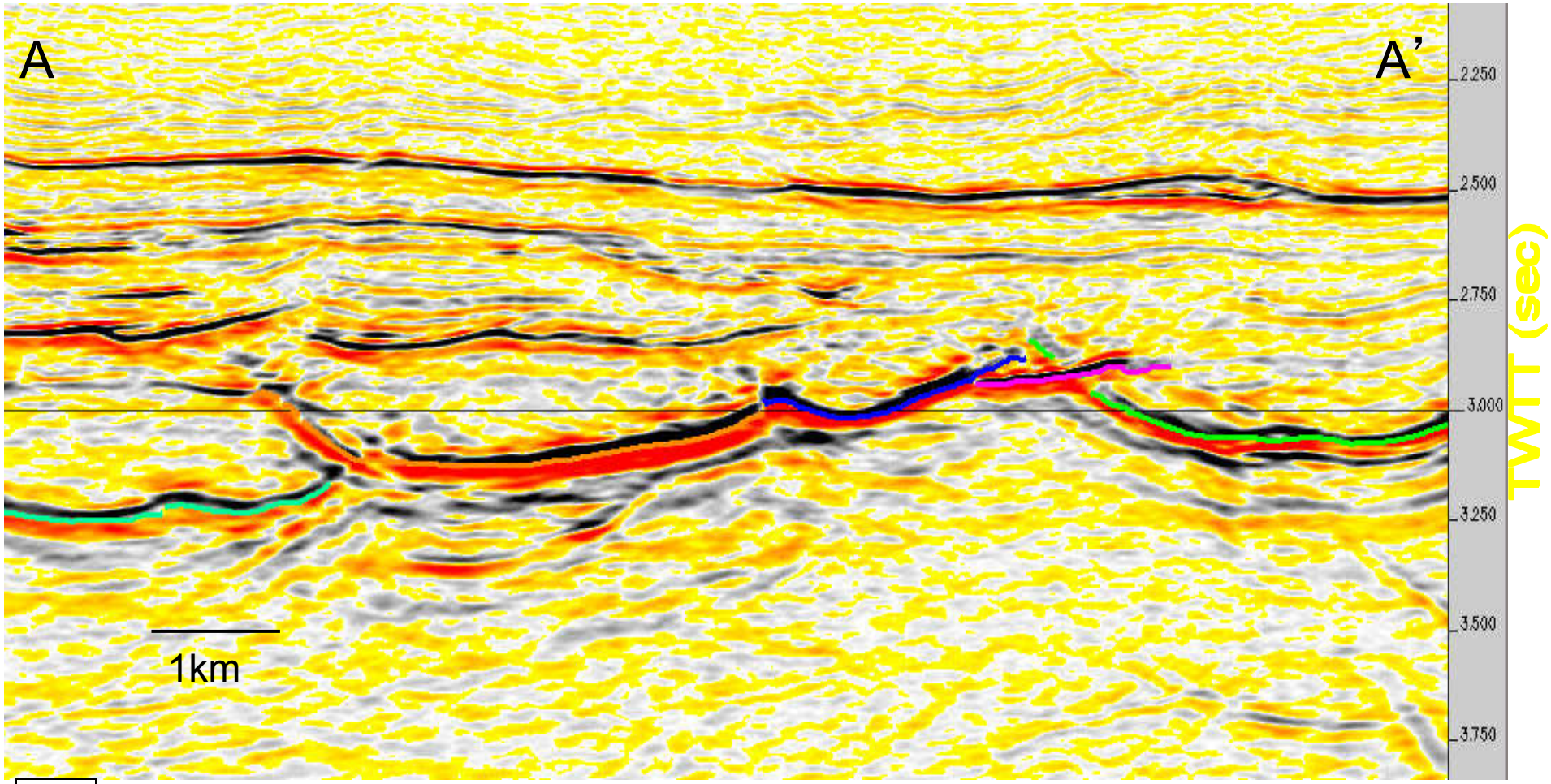
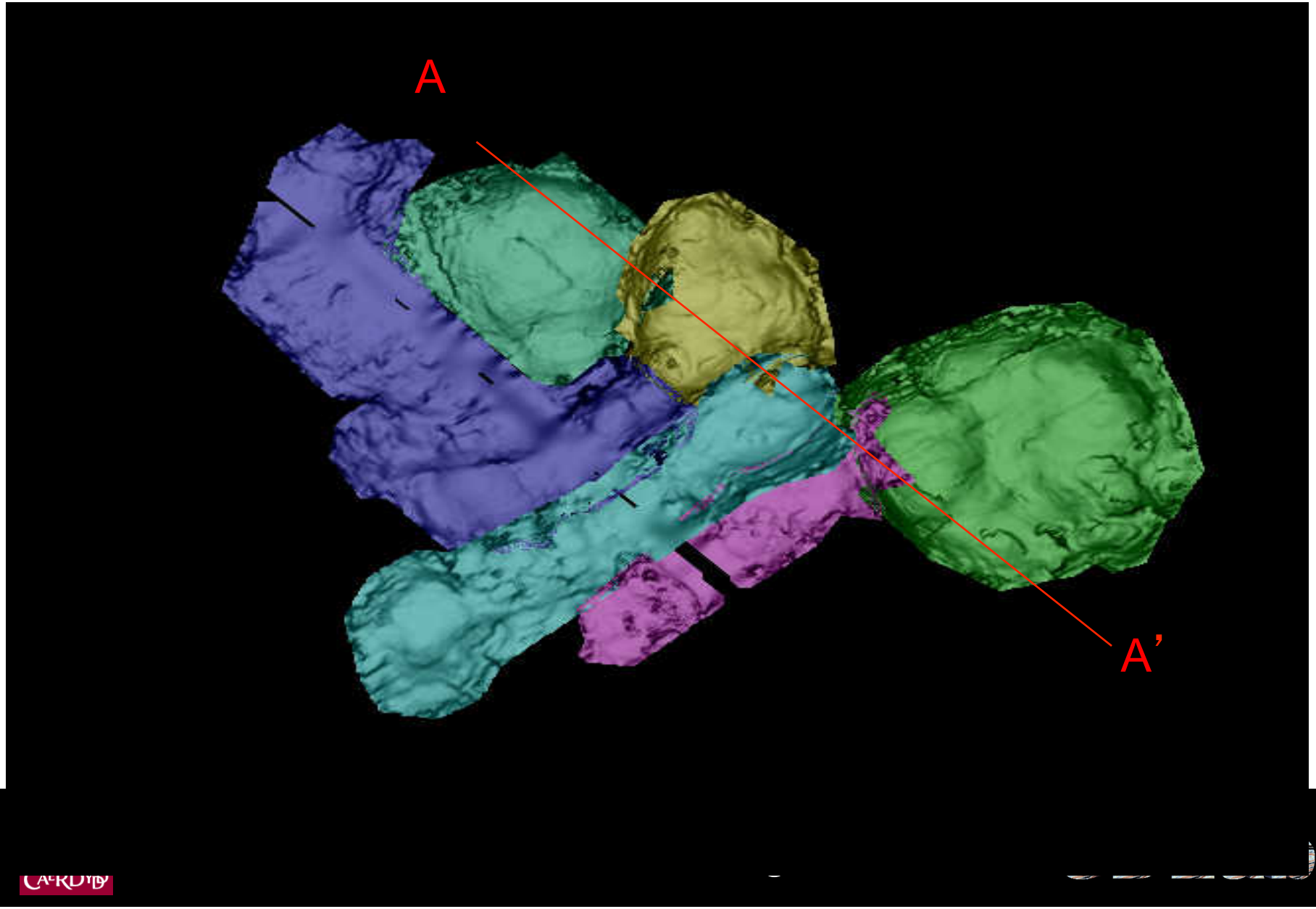

TRC 645 660 670 680 690 700 710 720 730 740 750 760 770 780 790 800 810 820 830 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000 1010 1023 TRC
CDP 11104 11150 11200 11250 11300 11350 11400 11450 11500 11550 11600 11650 11700 11750 11800 11860 CDP
2.968
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000
6.188
2 km
t61t5
t61class
ILN 4432
Time

Hansen et al 2004



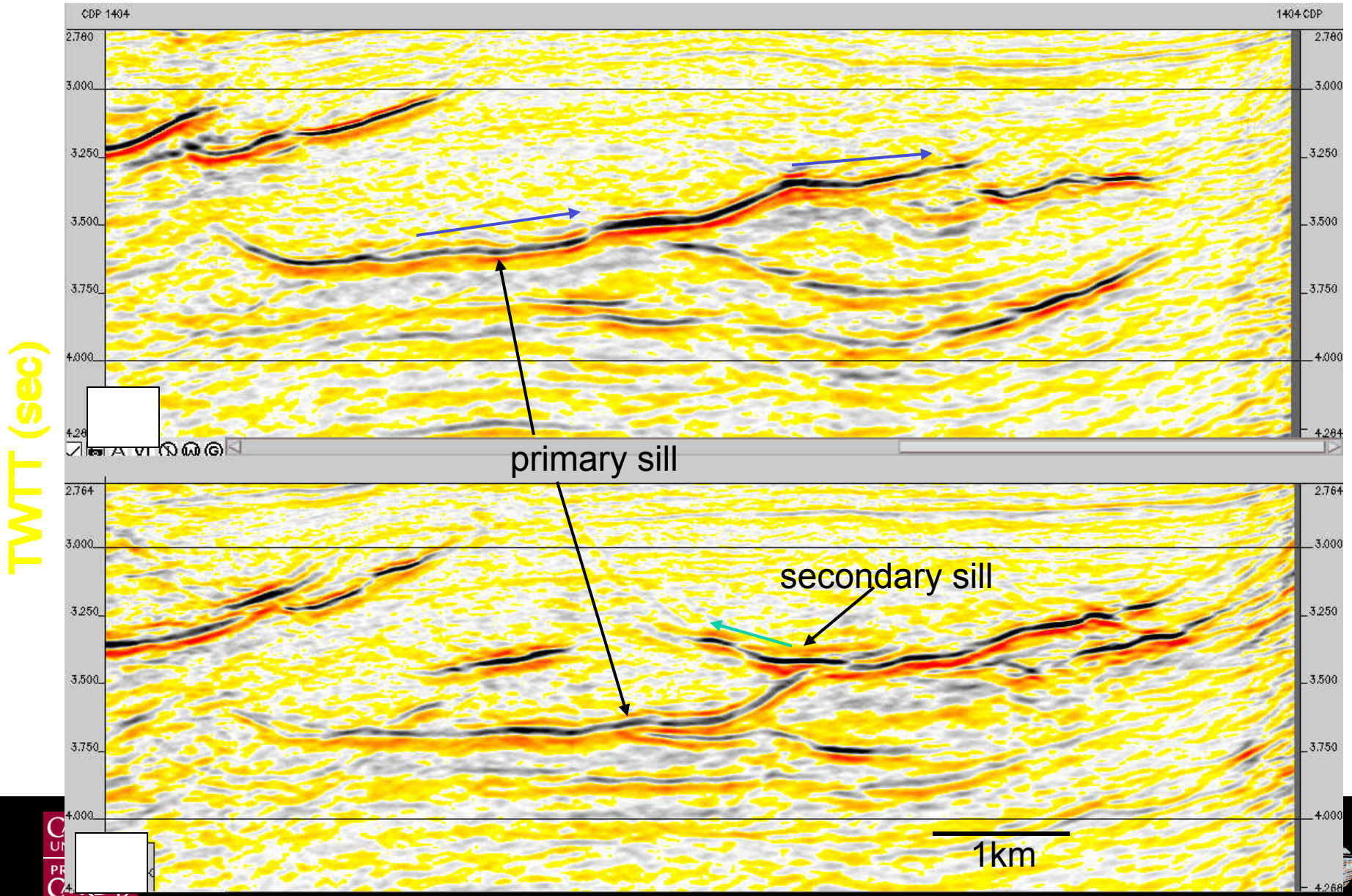
clustered sill geometries

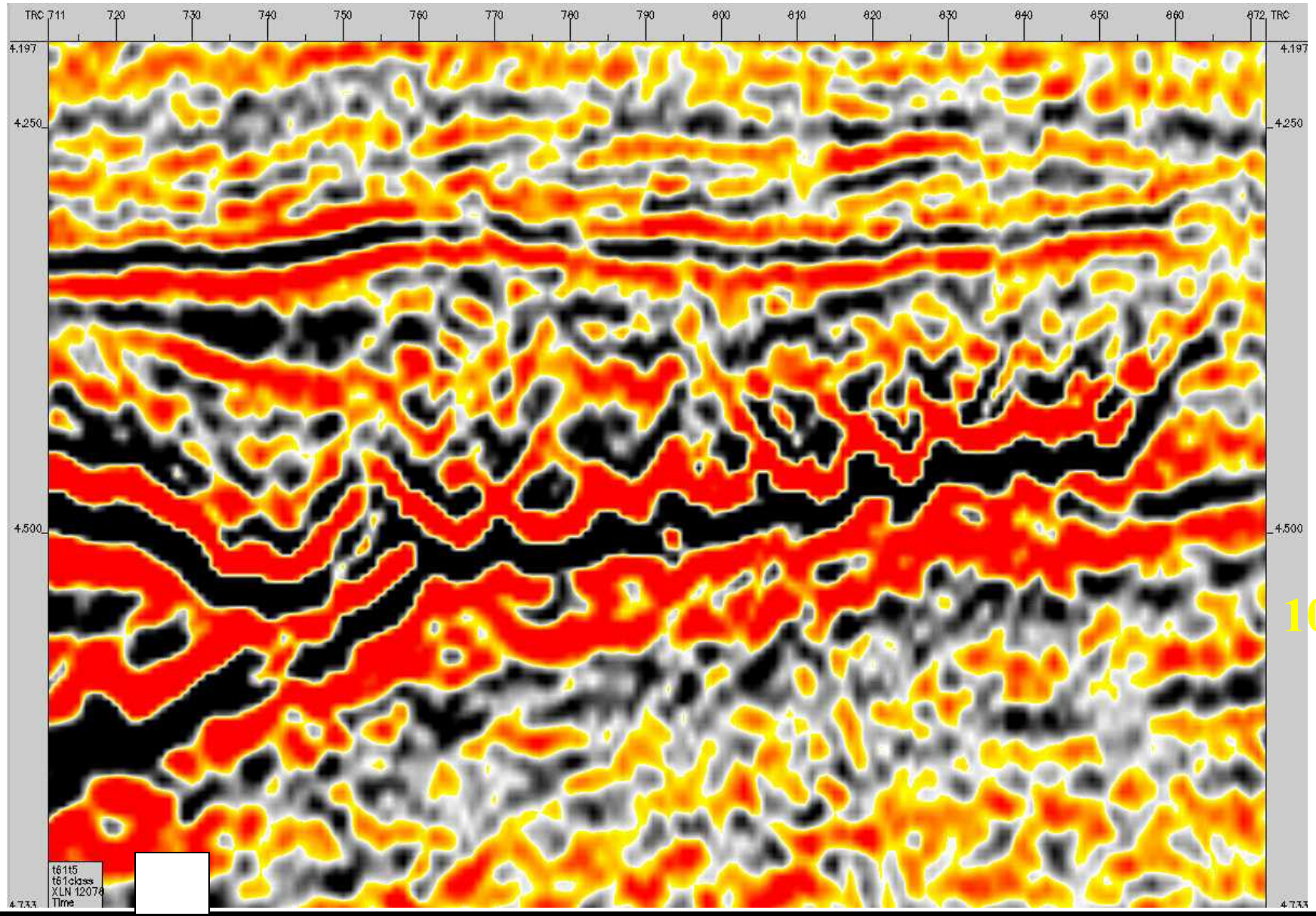
Hansen et al 2004



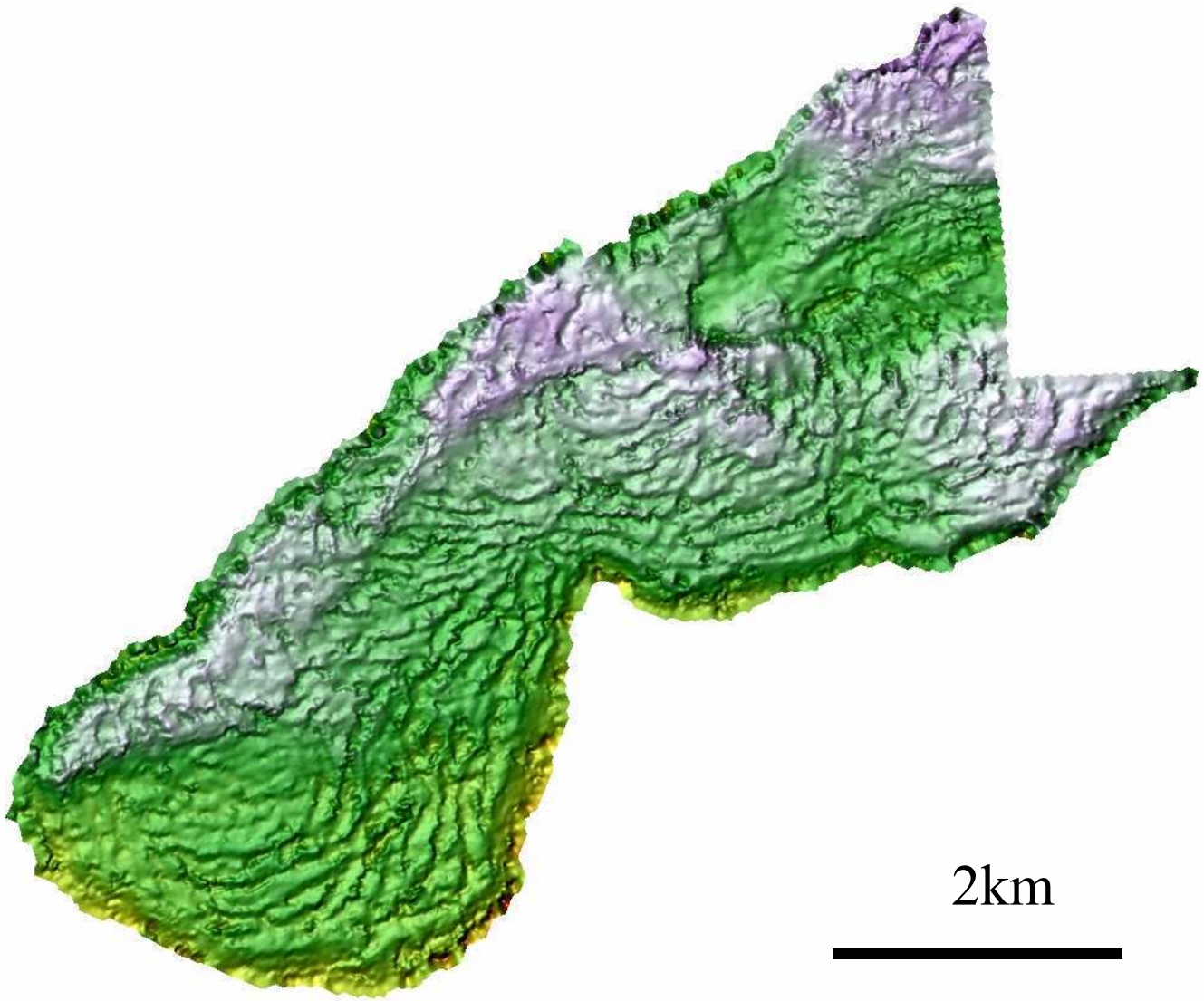
Feeder sills

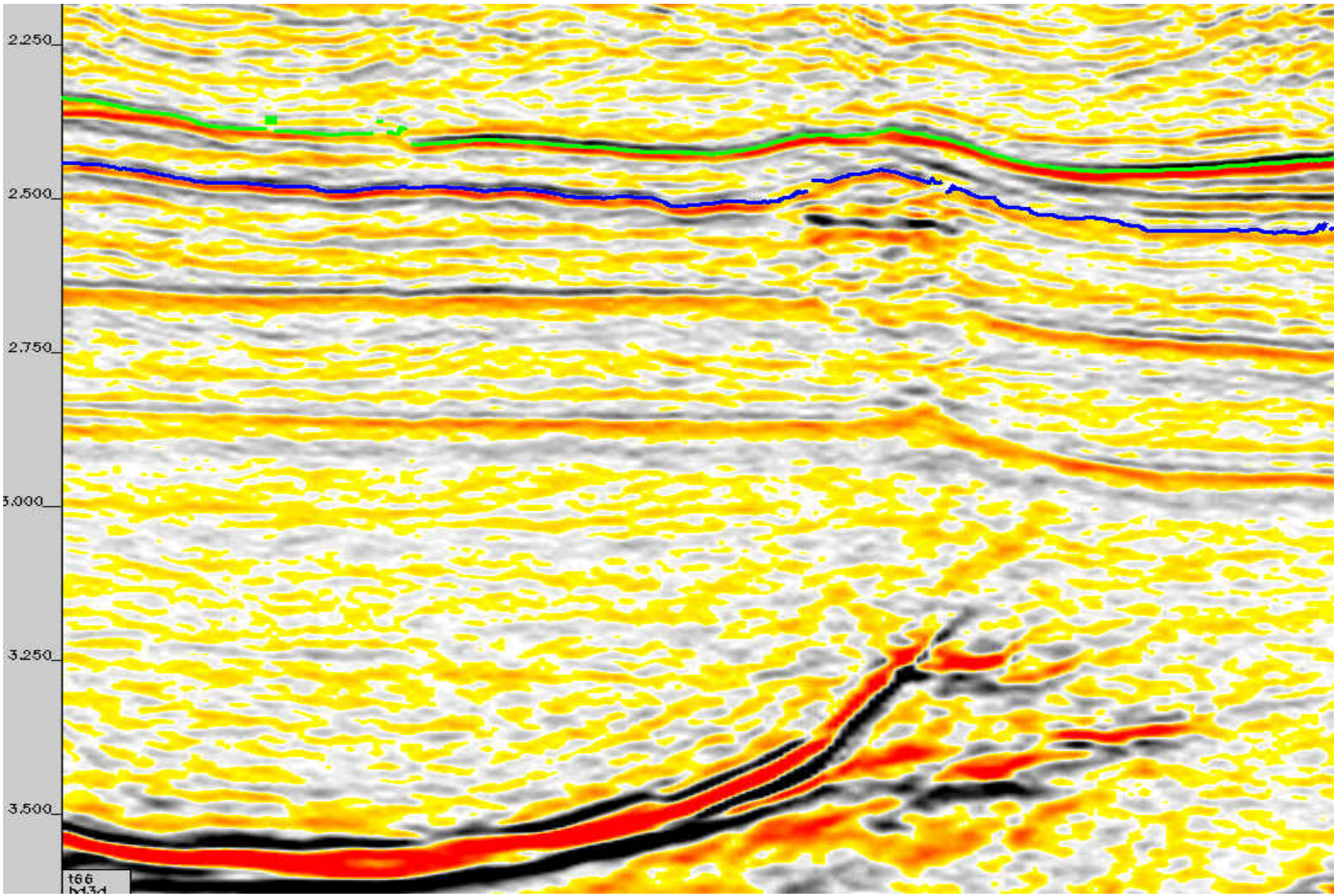
Hansen et al 2004

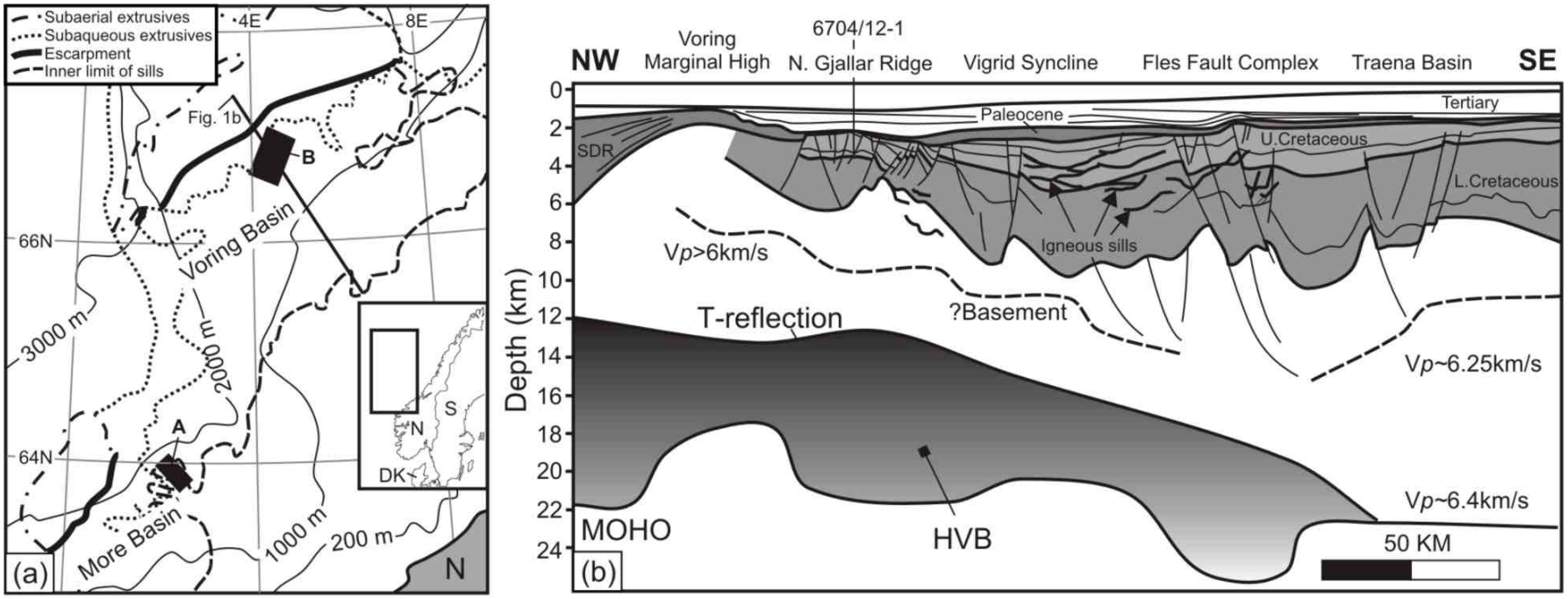



TRC 711
720
730
740
750
760
770
780
790
800
810
820
830
840
850
860
872 TRC
4.197
4.250
4.500
t61t5
t61class
XLN 12076
Time
100ms
2 km

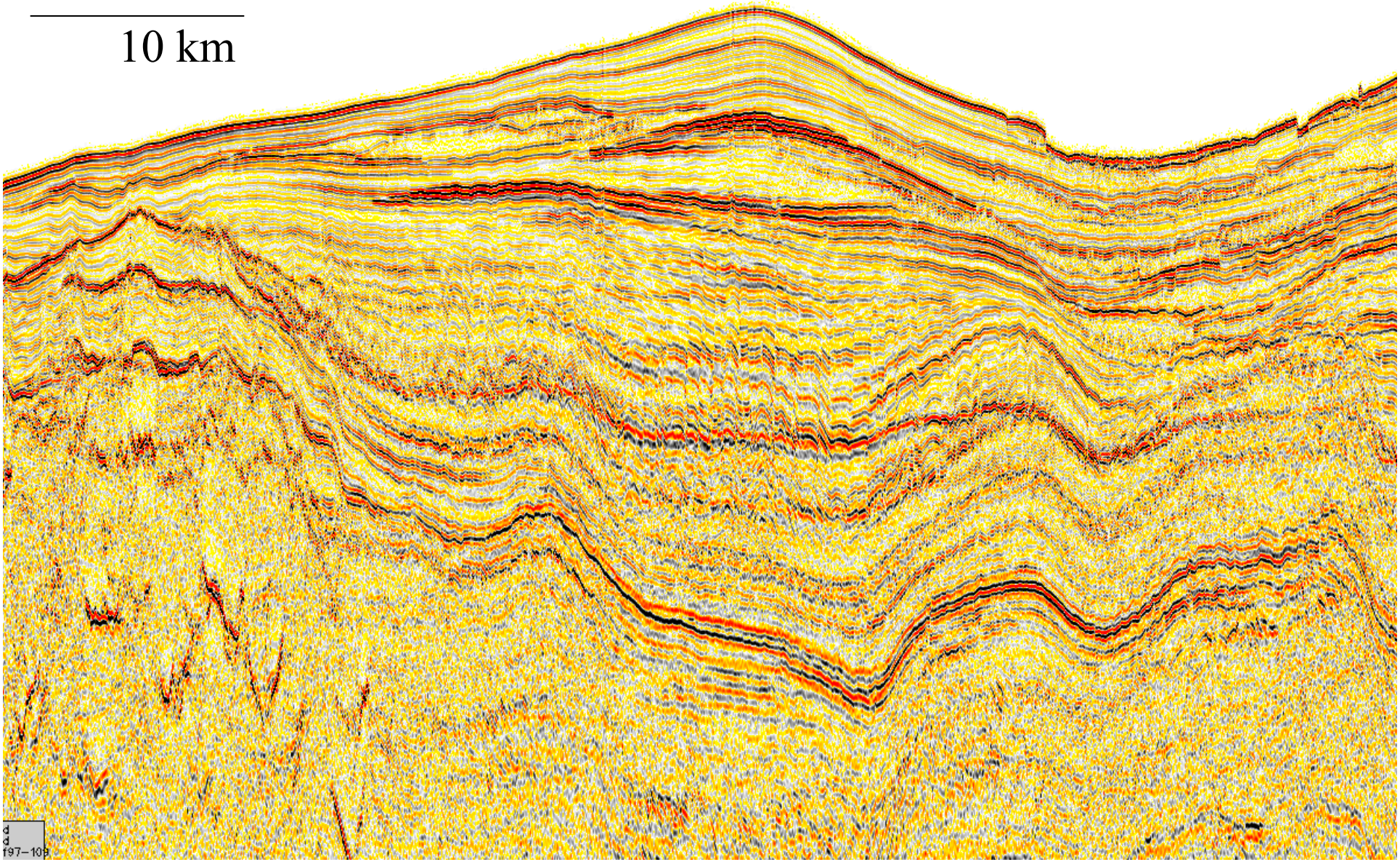
Ridged morphology of the Corona Sill: James Trude, 2004




2.250
2.500
2.750
3.000
3.250
3.500
t66
2 km



Cartwright & Hansen: Figure 1



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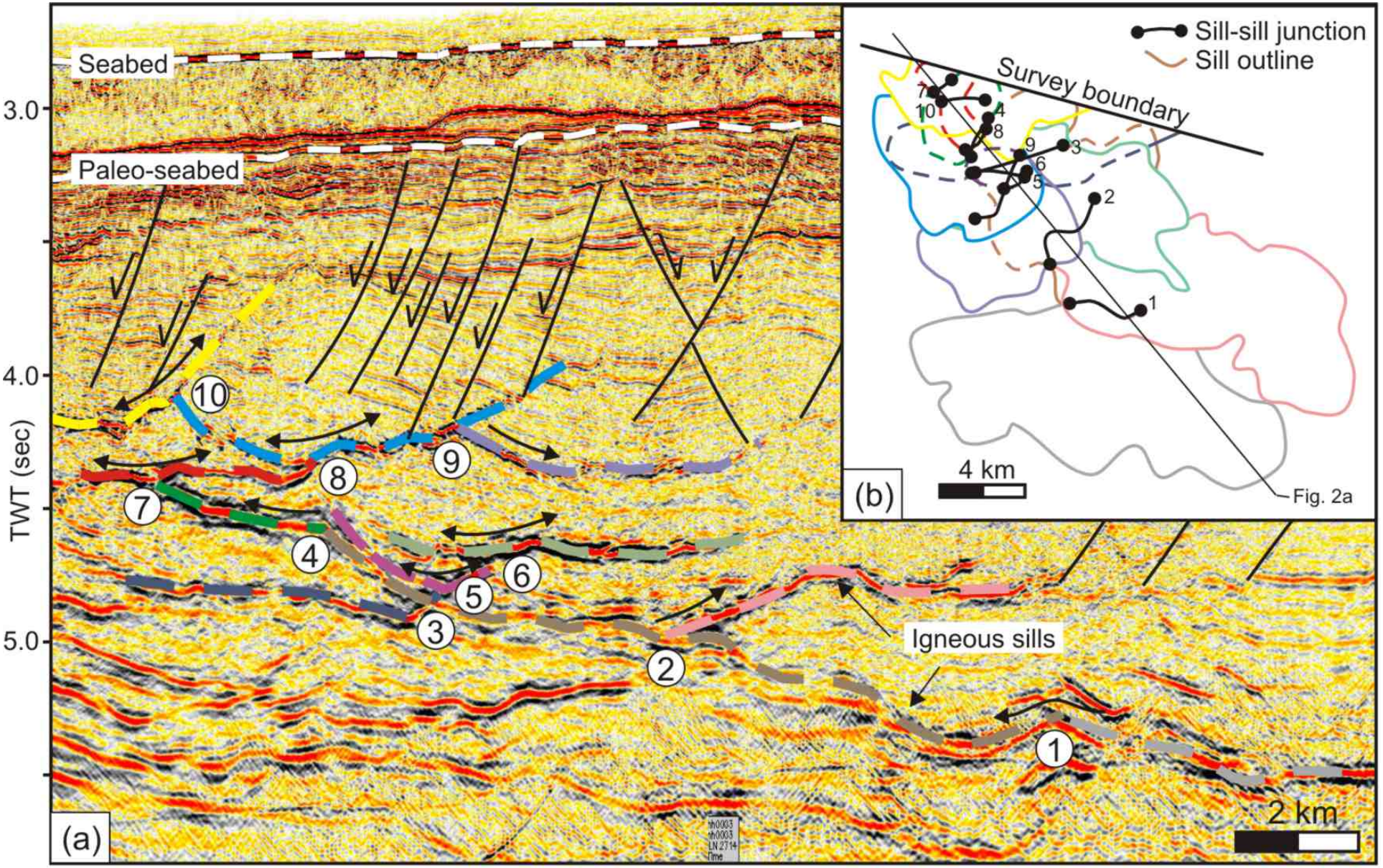
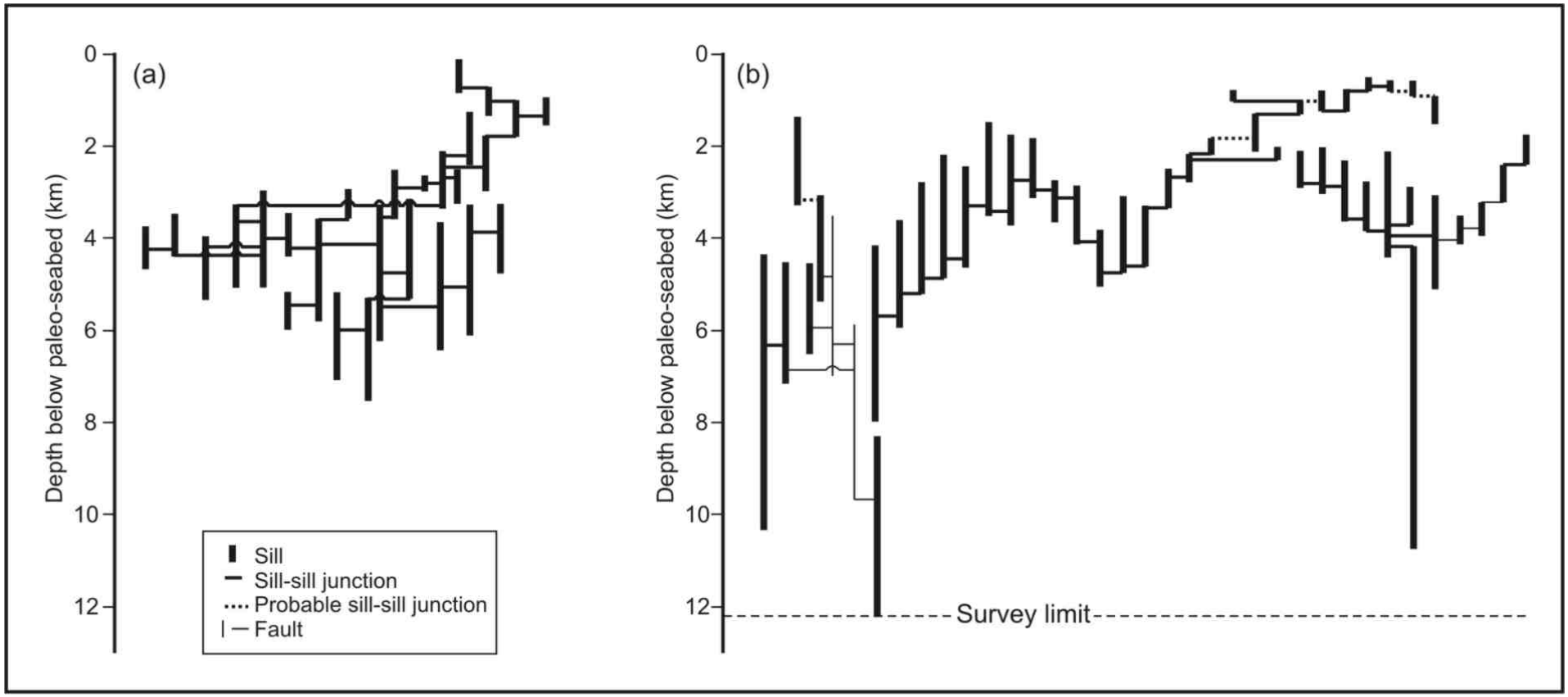


Cartwright & Hansen: Figure 2



Cartwright & Hansen: Figure 4

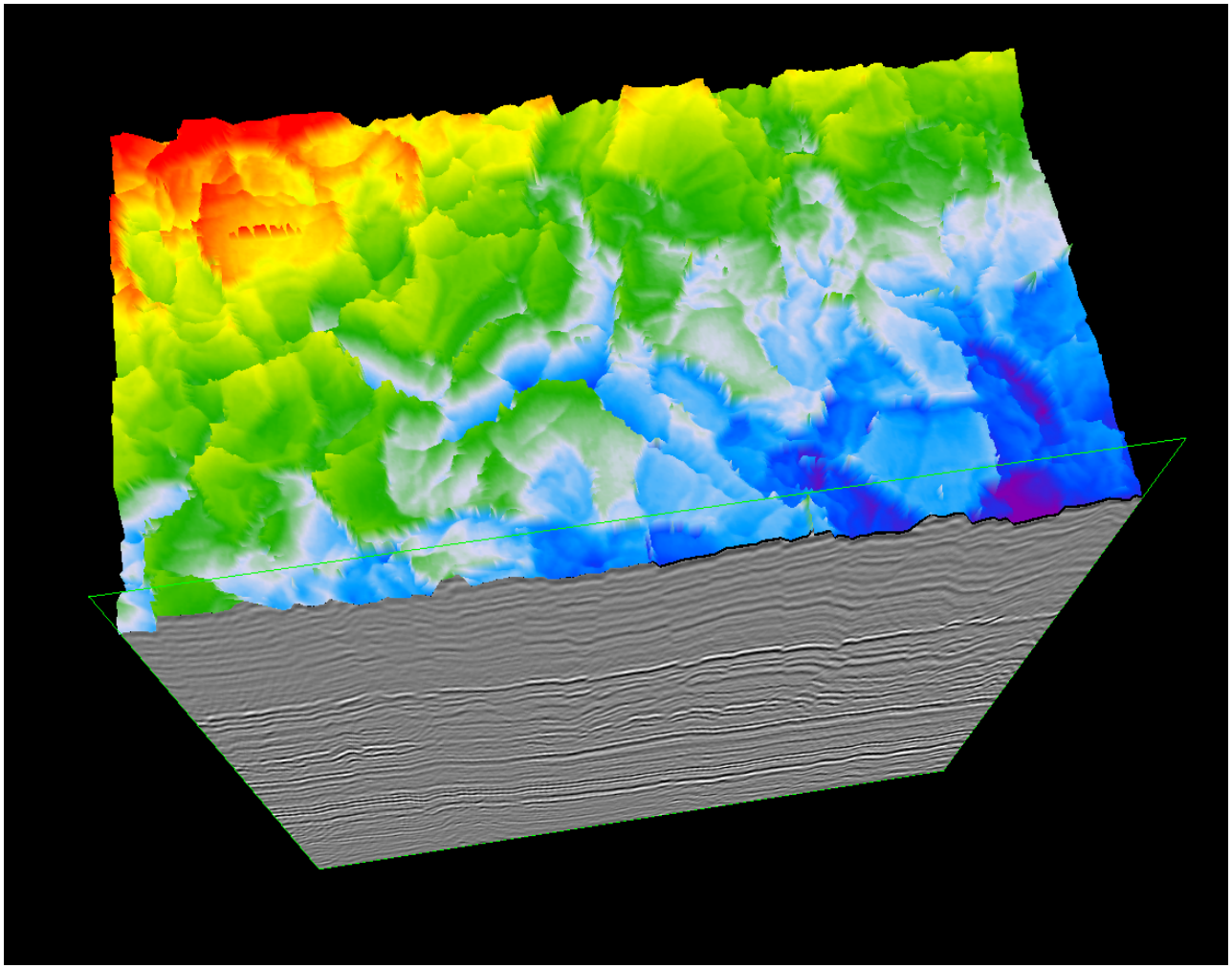
Basin hydrodynamics

How does fluid migrate in sedimentary basins?

How does fluid migration link with rock deformation and diagenesis?

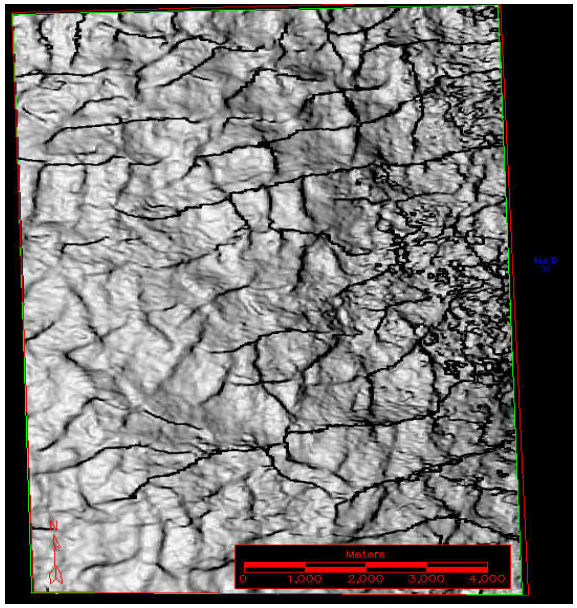
What is the mass balance?

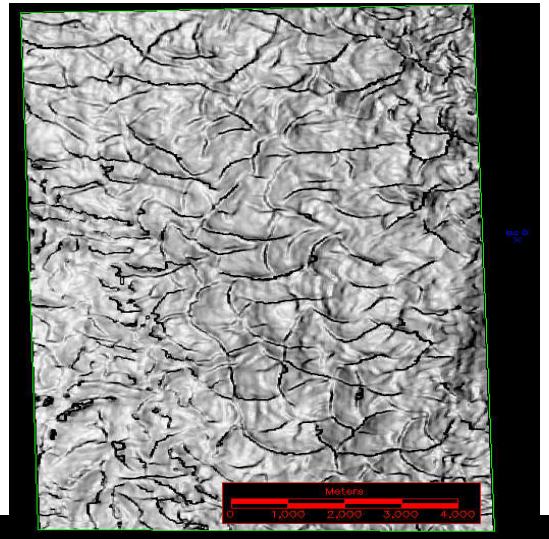
“Polygonal fault systems are arrays of layer bound extensional faults with a polygonal planform geometry”

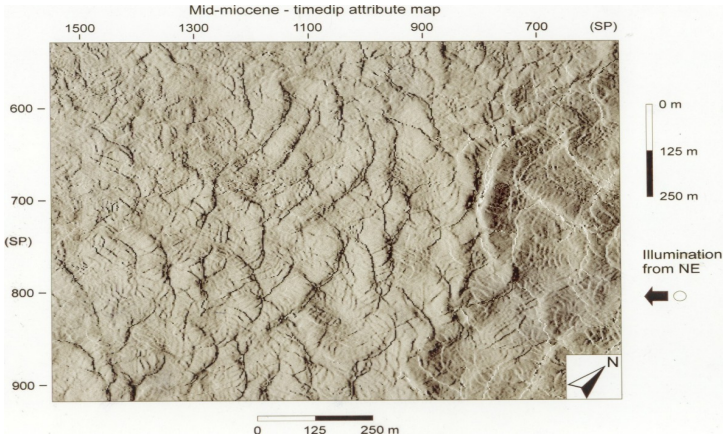


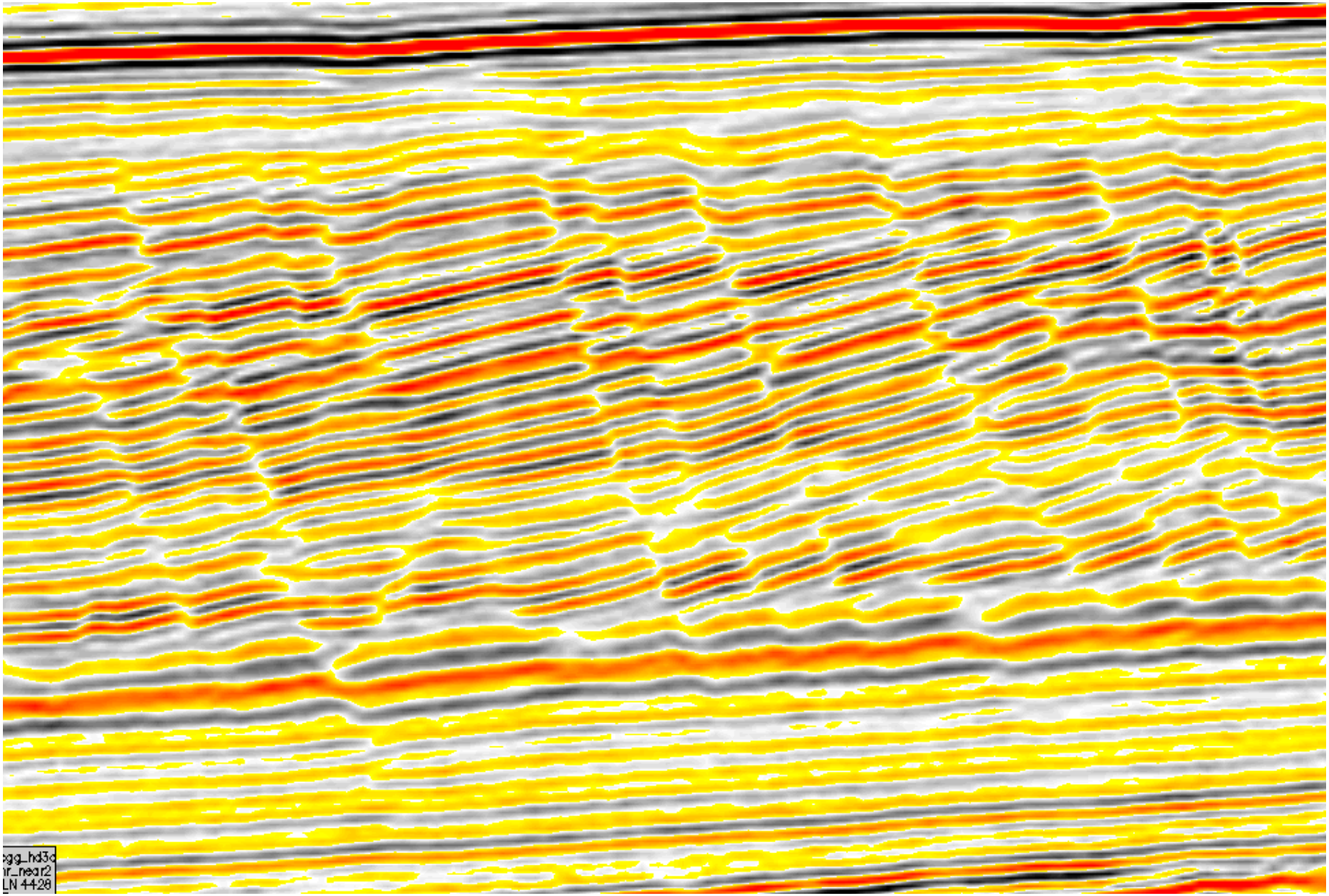
Global distribution of layer-bound and polygonal faults

3 km


Meters
0 1,000 2,000 3,000 4,000


Meters
0 1,000 2,000 3,000 4,000


Mid-miocene - timedip attribute map
1500
1300
1100
900
700
(SP)
600
700
(SP)
800
900
0 m
125 m
250 m
Illumination
from NE
N
0
125
250 m



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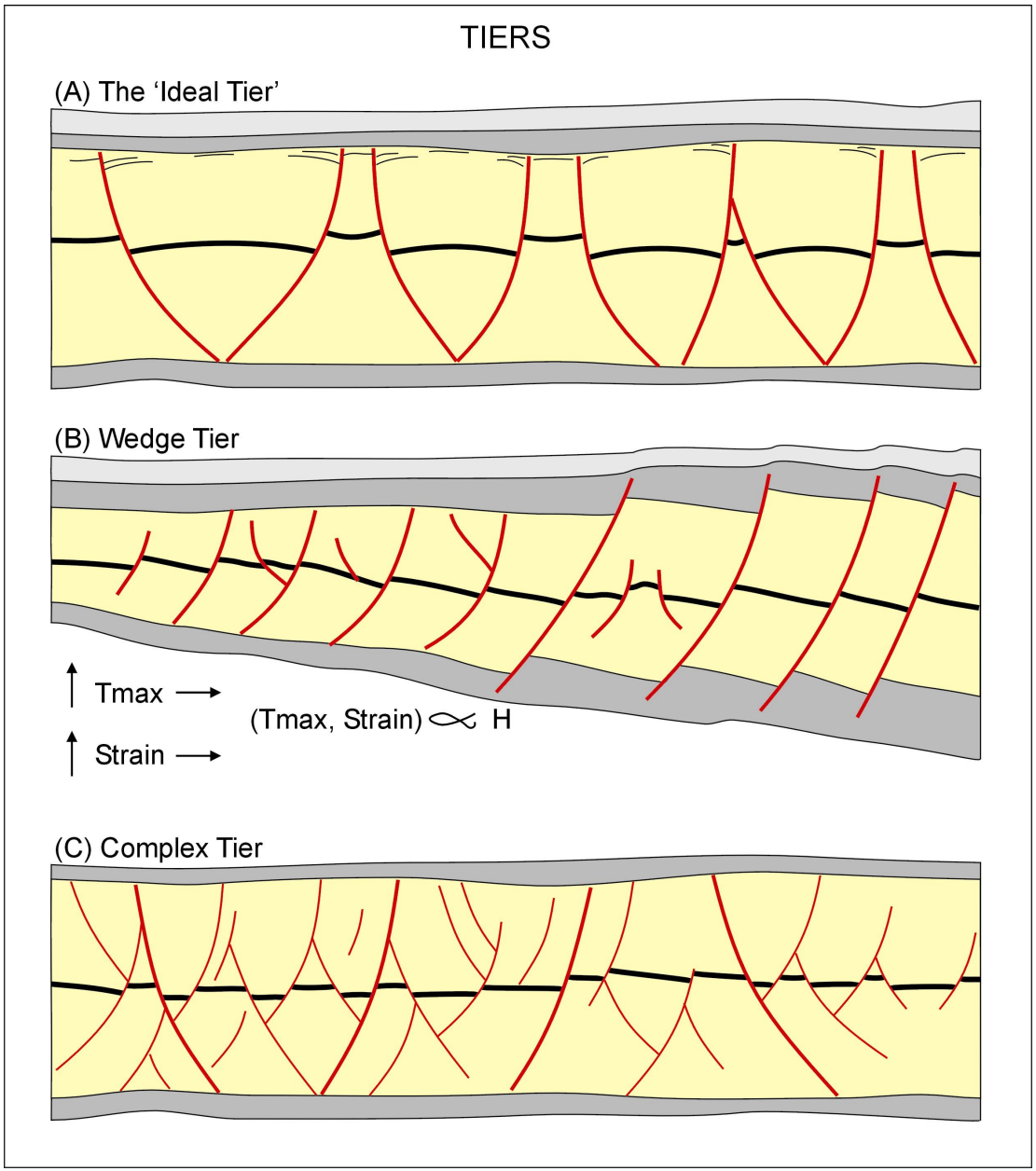
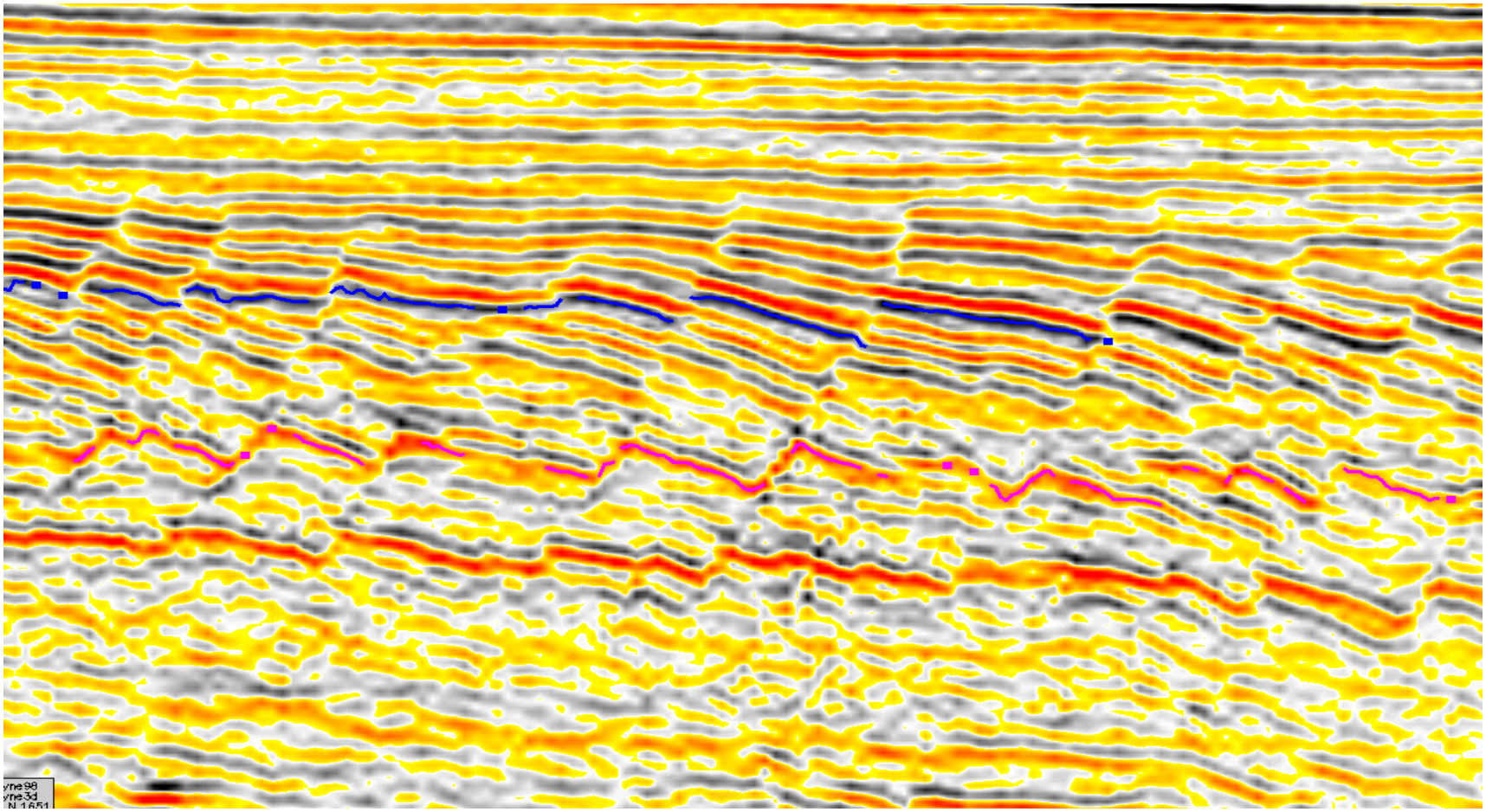
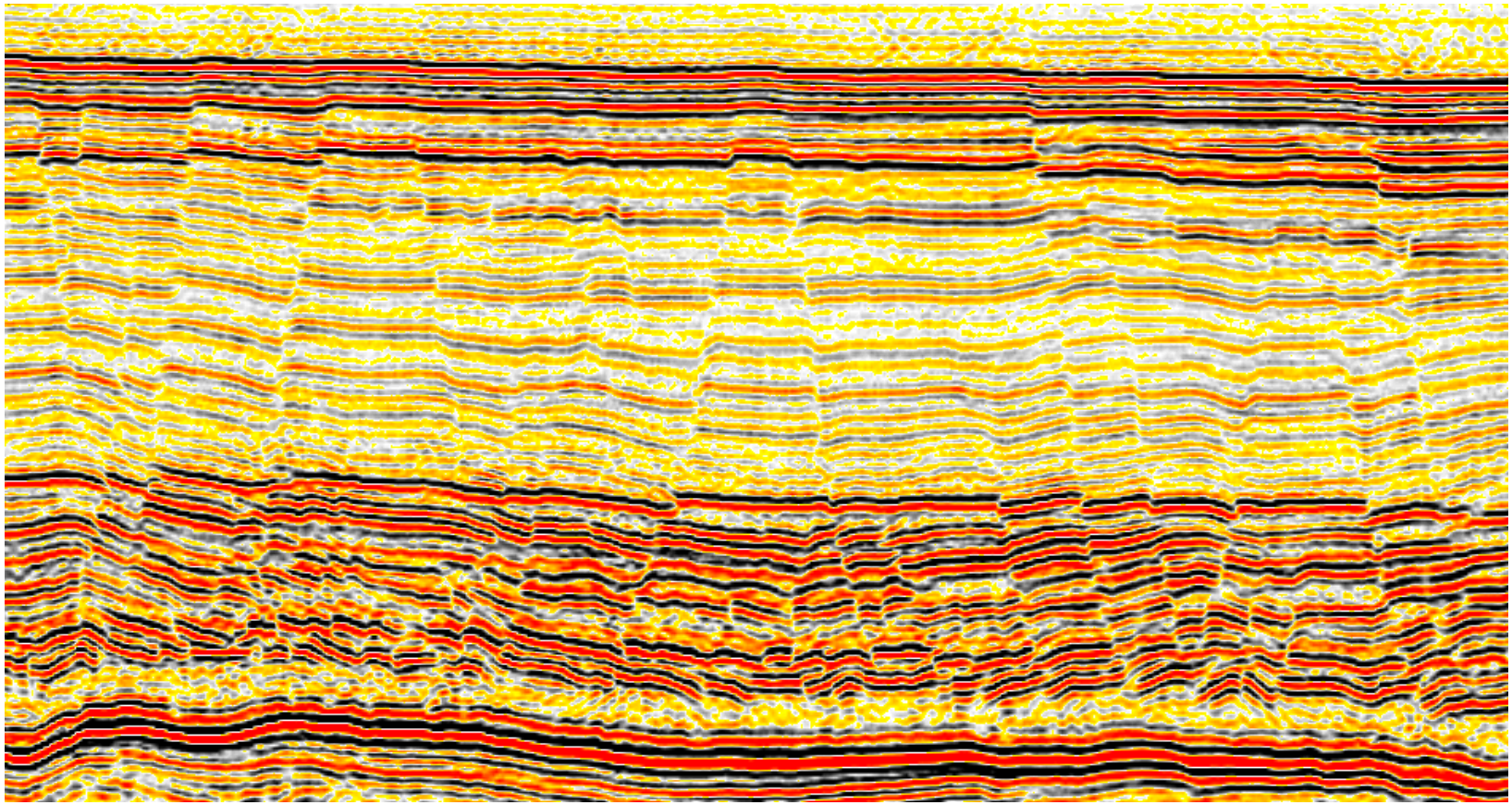
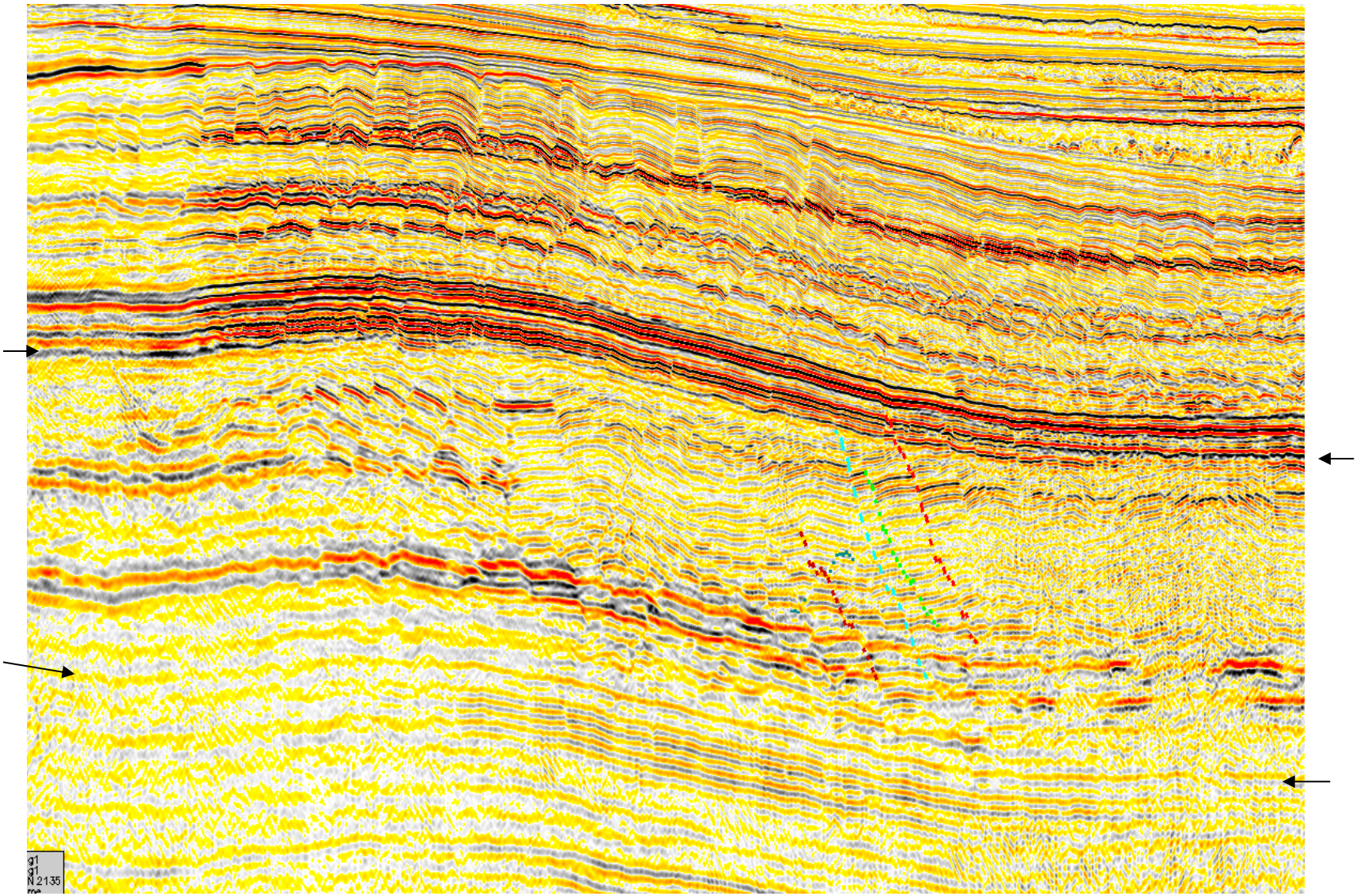

TIERS
(A) The 'Ideal Tier'
(B) Wedge Tier
Tmax
Strain
(Tmax, Strain) ∝ H
(C) Complex Tier



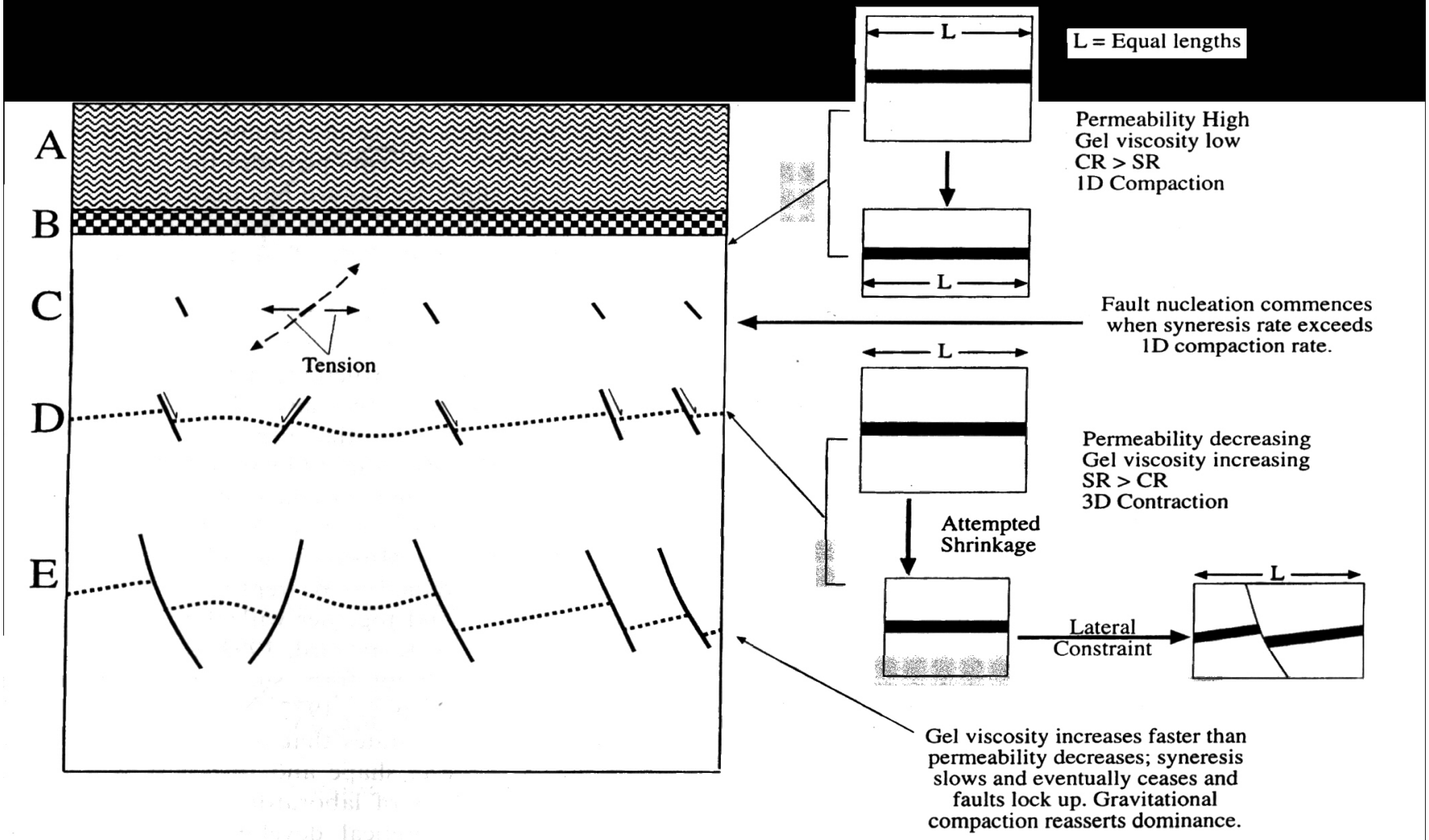
250ms

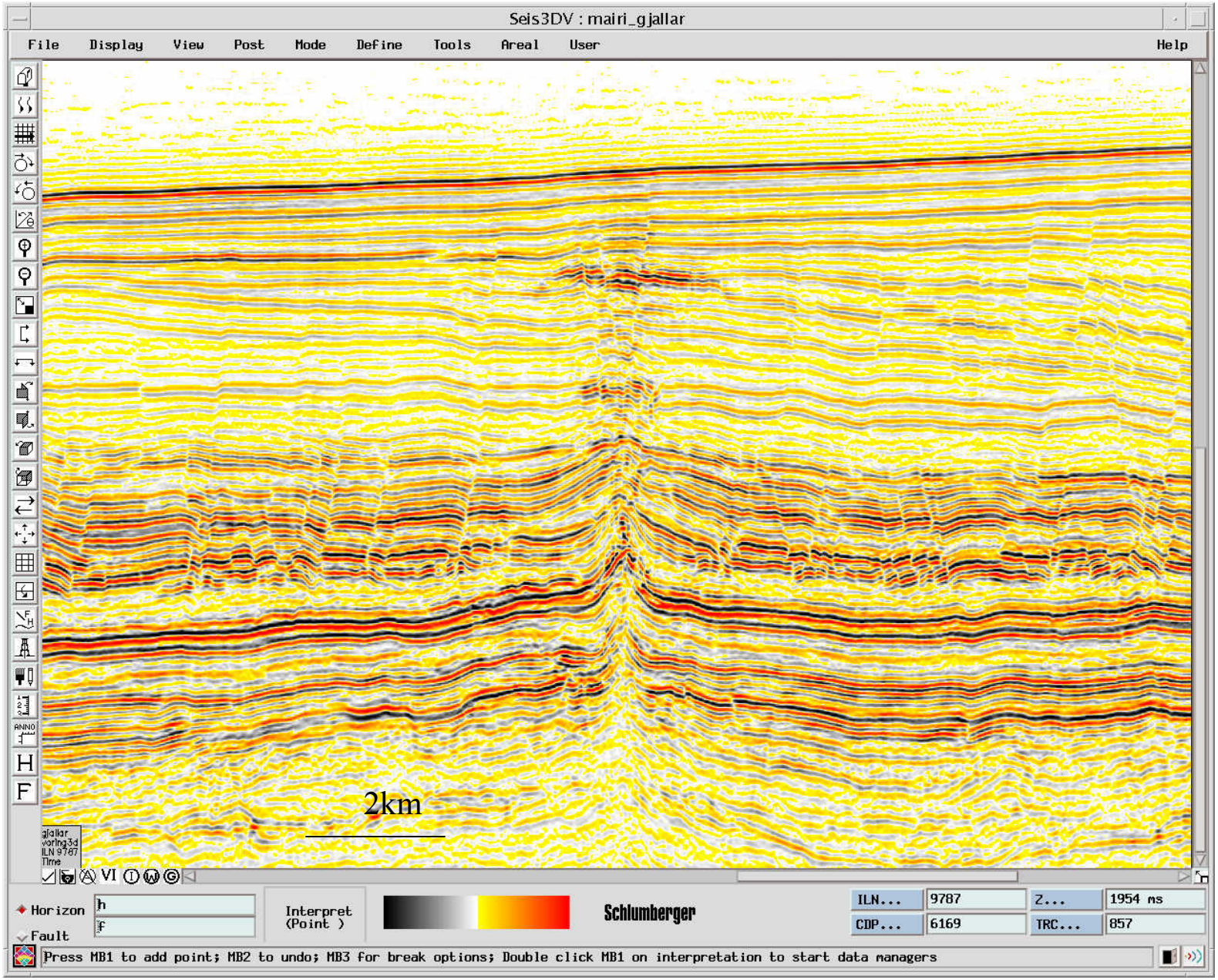


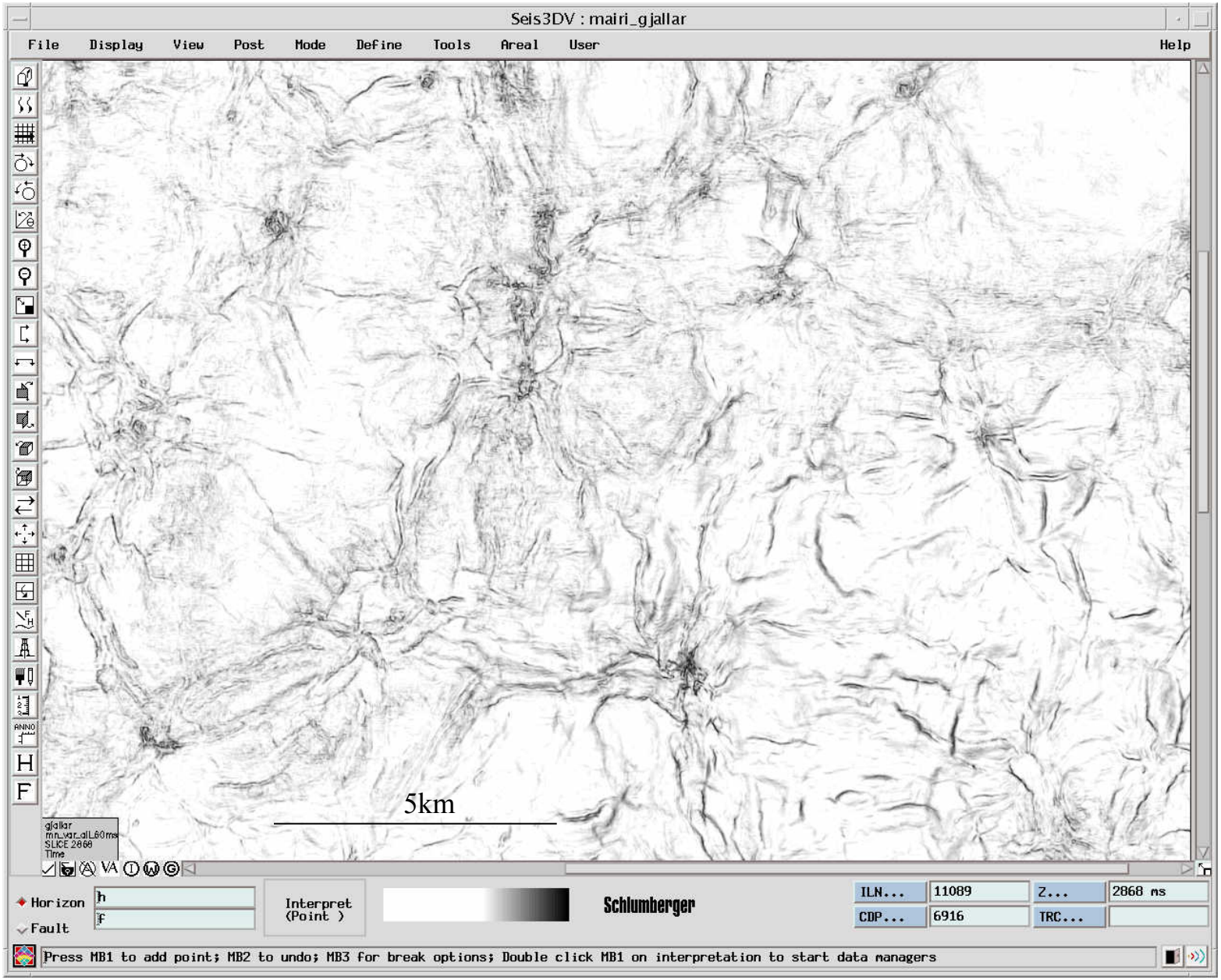
1km



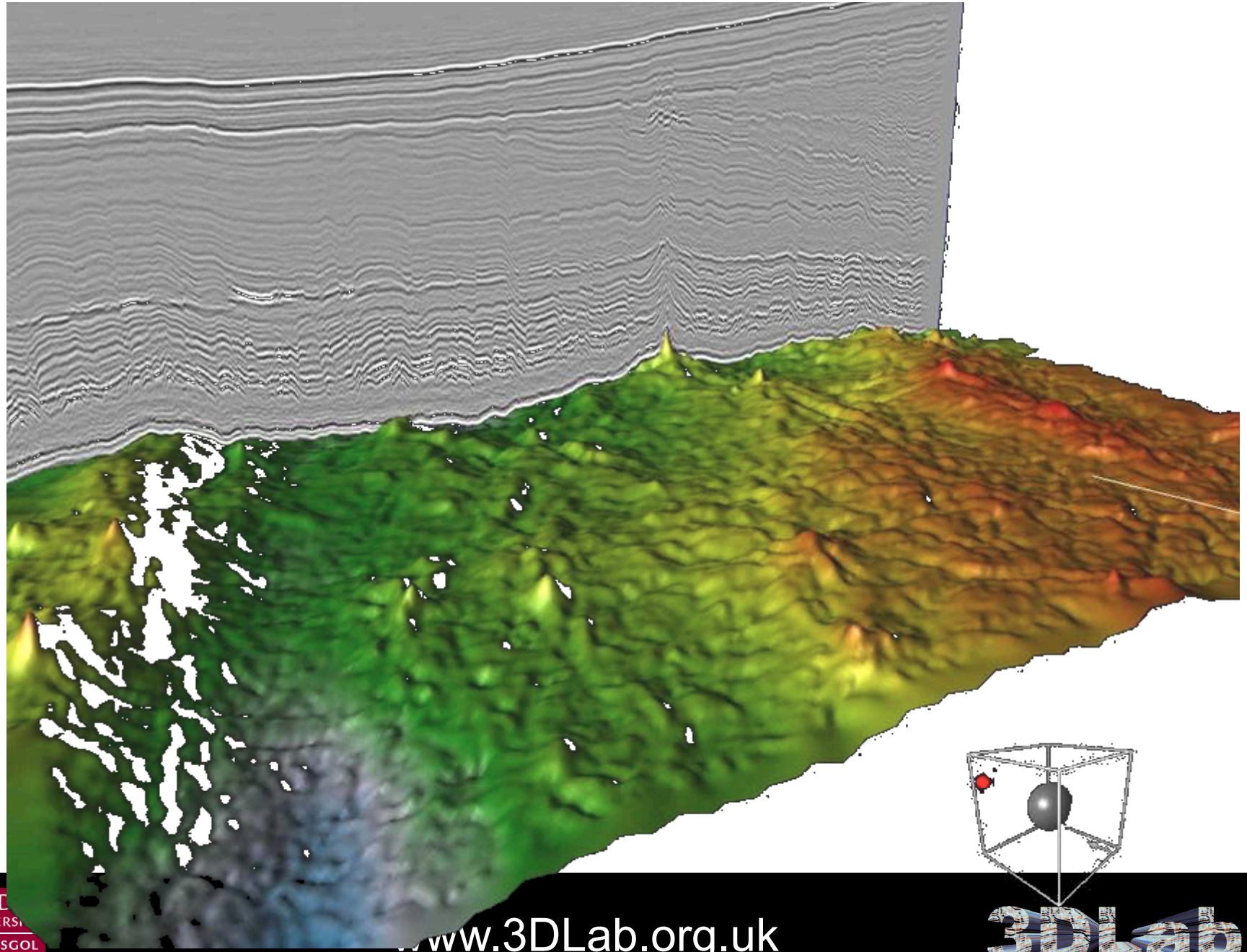
5km

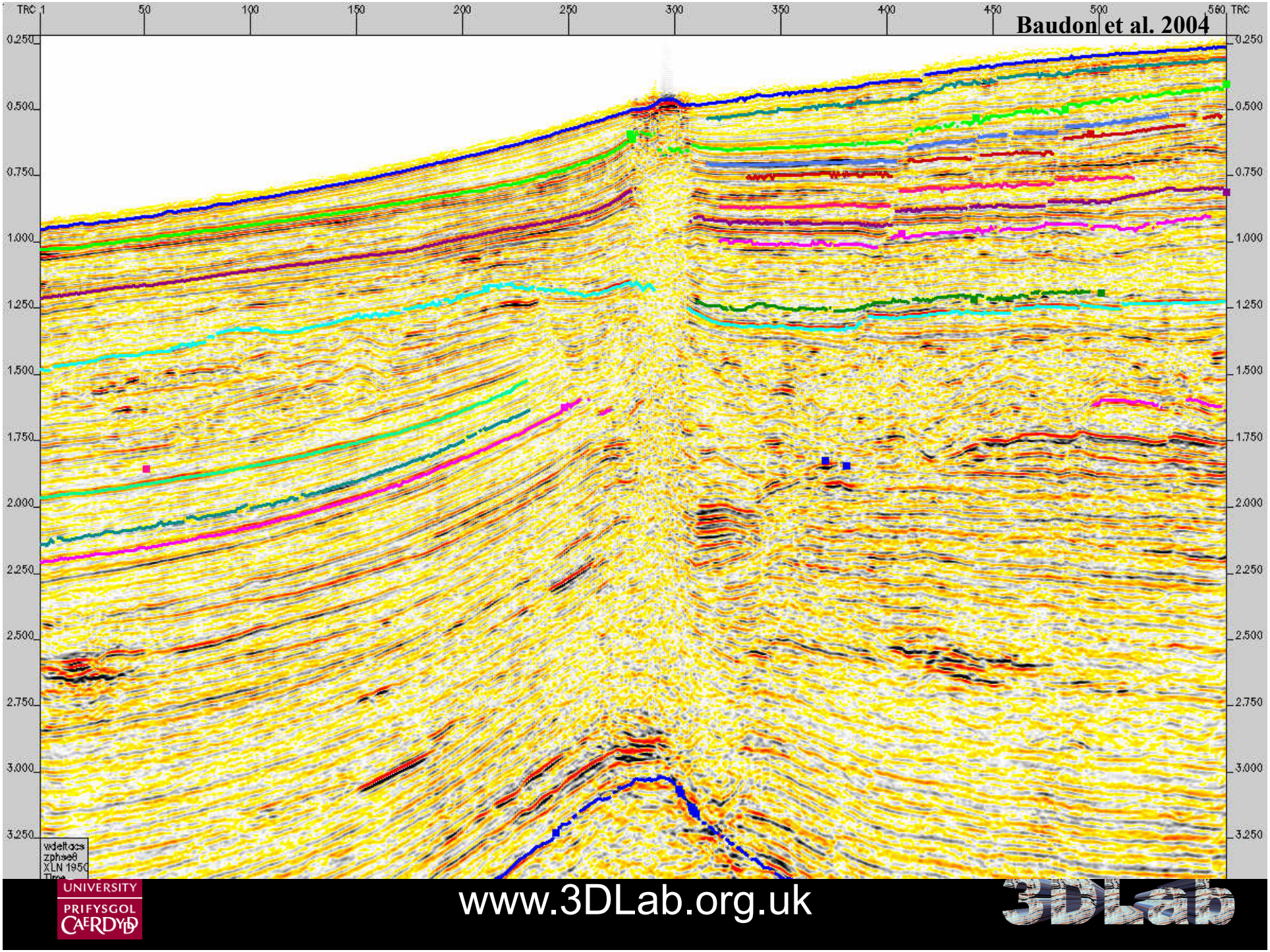

L
L = Equal lengths
A
B
C
D
E
Tension
Permeability High
Gel viscosity low
CR > SR
1D Compaction
L
Fault nucleation commences
when syneresis rate exceeds
1D compaction rate.
L
Permeability decreasing
Gel viscosity increasing
SR > CR
3D Contraction
Attempted
Shrinkage
L
Lateral
Constraint
Gel viscosity increases faster than
permeability decreases; syneresis
slows and eventually ceases and
faults lock up. Gravitational
compaction reasserts dominance.


Seis3DV : mairi_gjallar
File
Display
View
Post
Mode
Define
Tools
Areal
User
Help
500ms
2km
Horizon
Fault
Interpret
(Point)
Schlumberger
ILN...
9787
Z...
1954 ms
CDP...
6169
TRC...
857
Press MB1 to add point; MB2 to undo; MB3 for break options; Double click MB1 on interpretation to start data managers


Seis3DV : mairi_gjallar
File
Display
View
Post
Mode
Define
Tools
Areal
User
Help
5km
gjallar
mn_var_gIL60ms
SLICE 2868
Time
Horizon
Fault
Interpret
(Point)
Schlumberger
ILN...
11089
Z...
2868 ms
CDP...
6916
TRC...
Press MB1 to add point; MB2 to undo; MB3 for break options; Double click MB1 on interpretation to start data managers

J.P. Hansen et al in press




Baudon et al. 2004
TRC 1
50
100
150
200
250
300
350
400
450
500
560 TRC
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
wdeltacs
zphase8
XLN 1950
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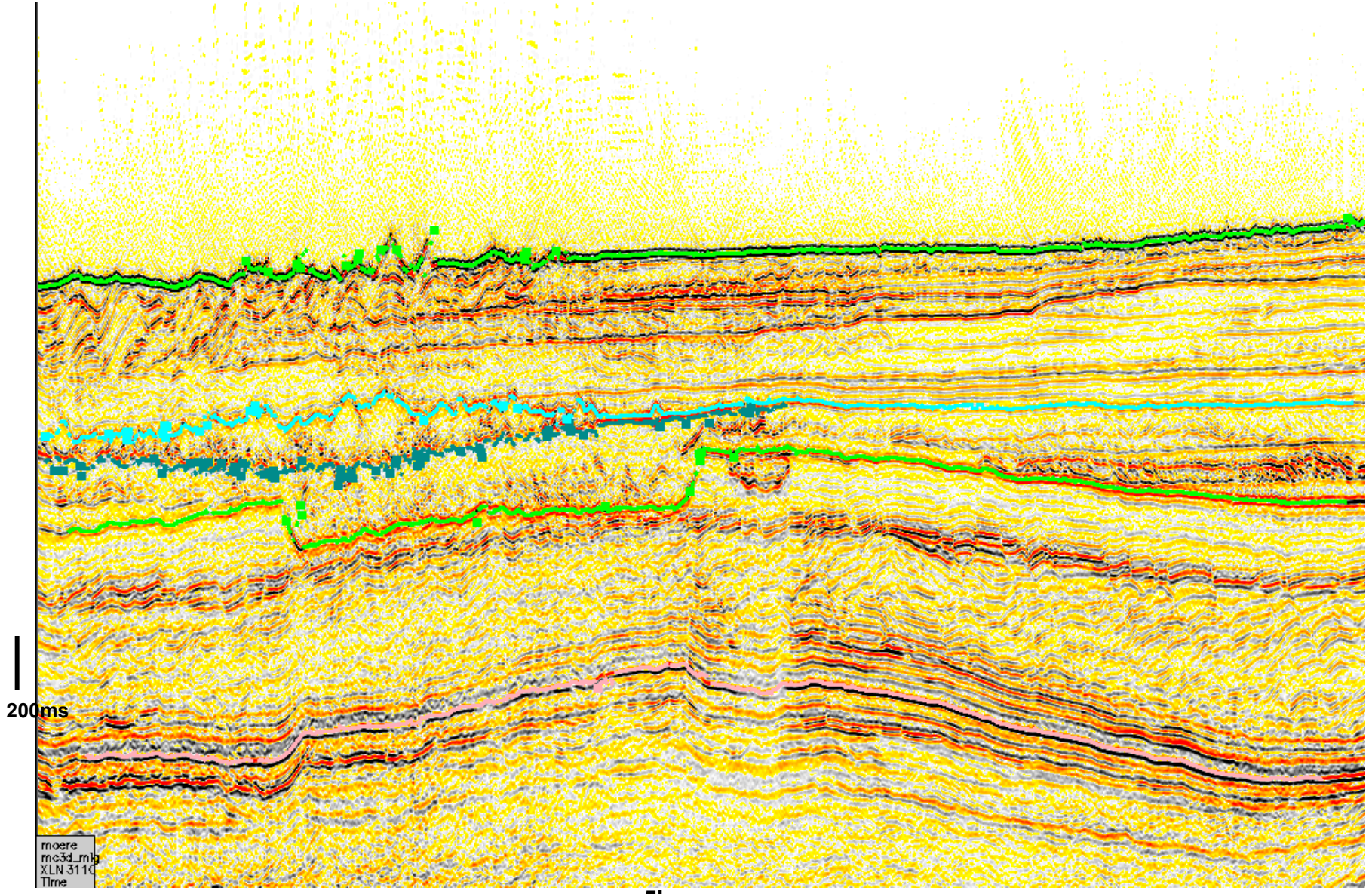
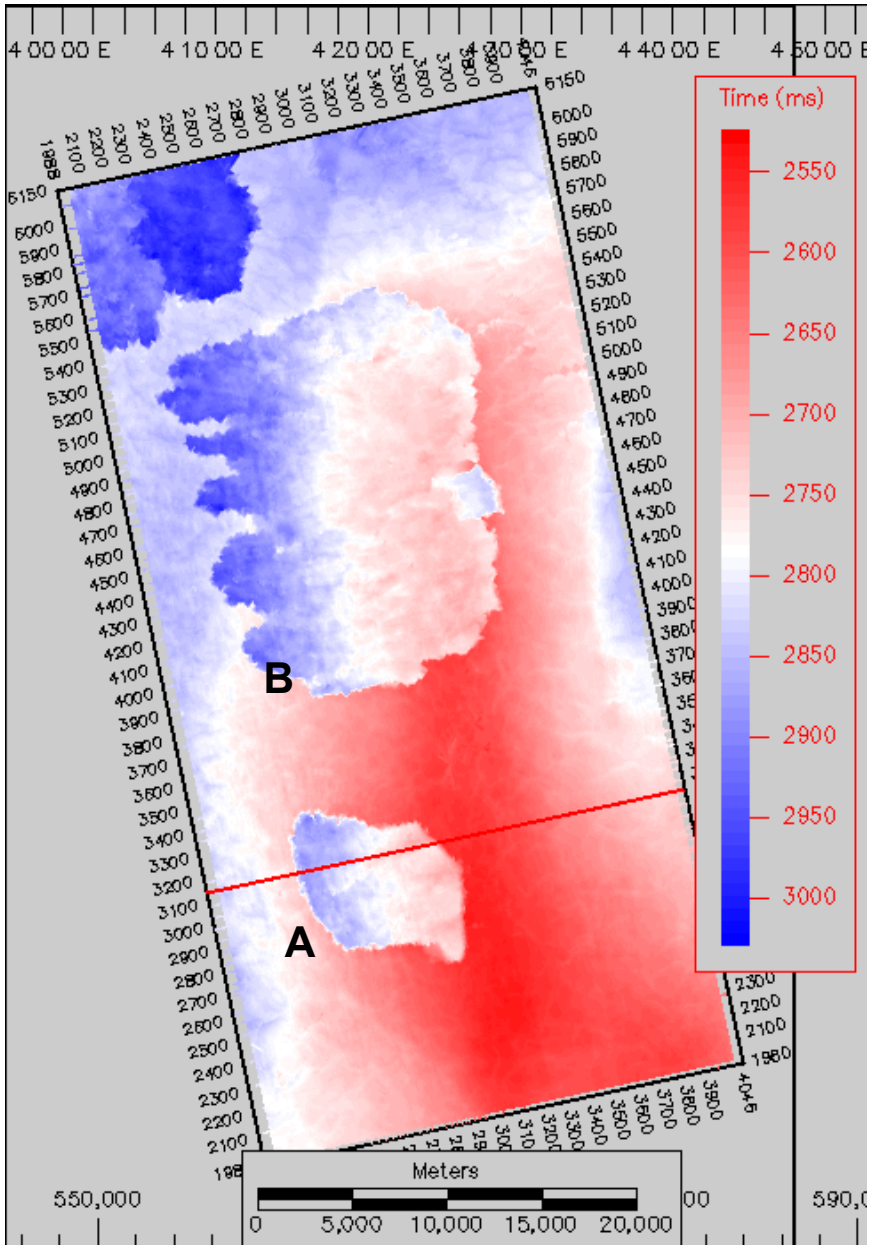
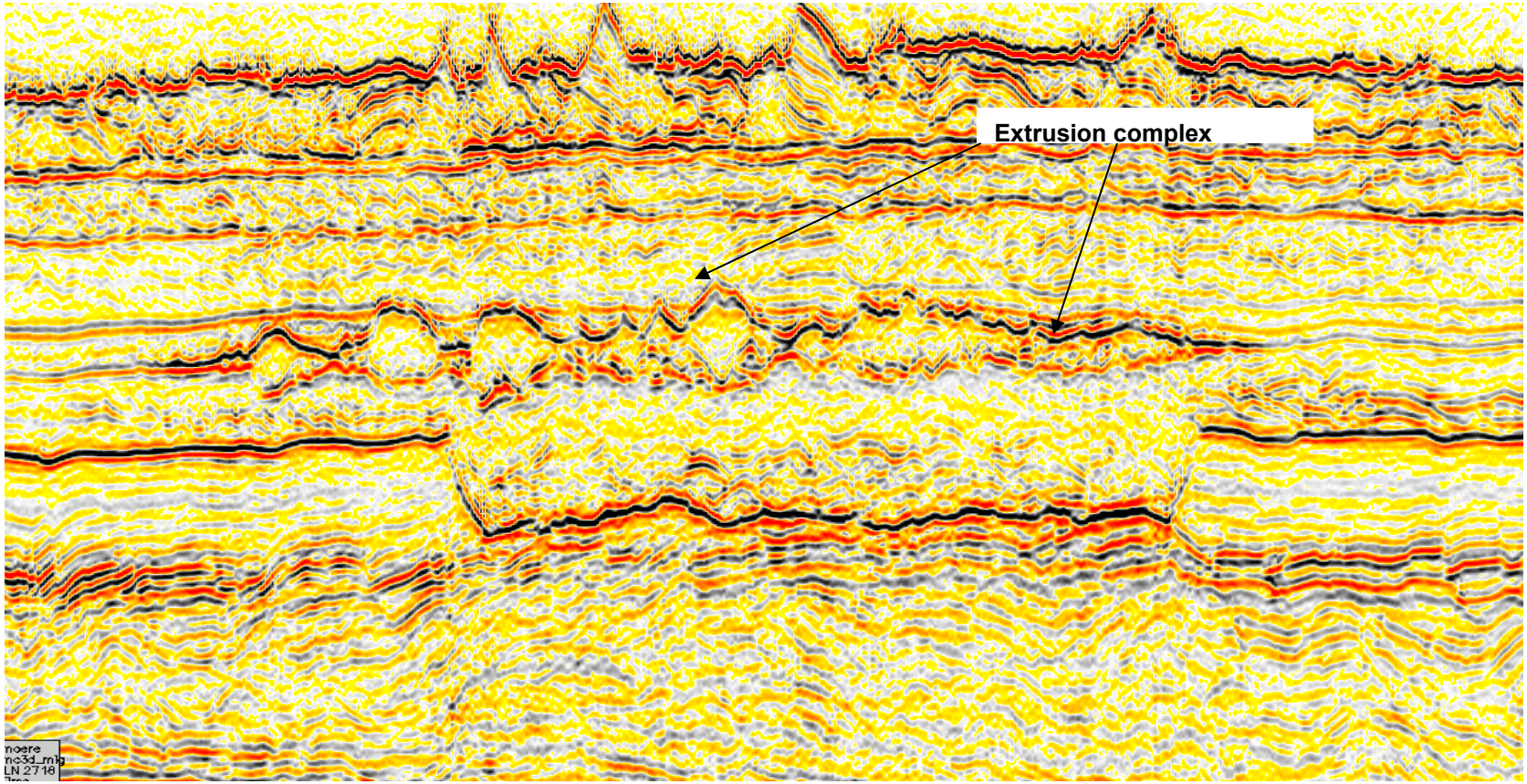

200ms
moere
mc3d_mig
XLN 3110
Time
5km
E

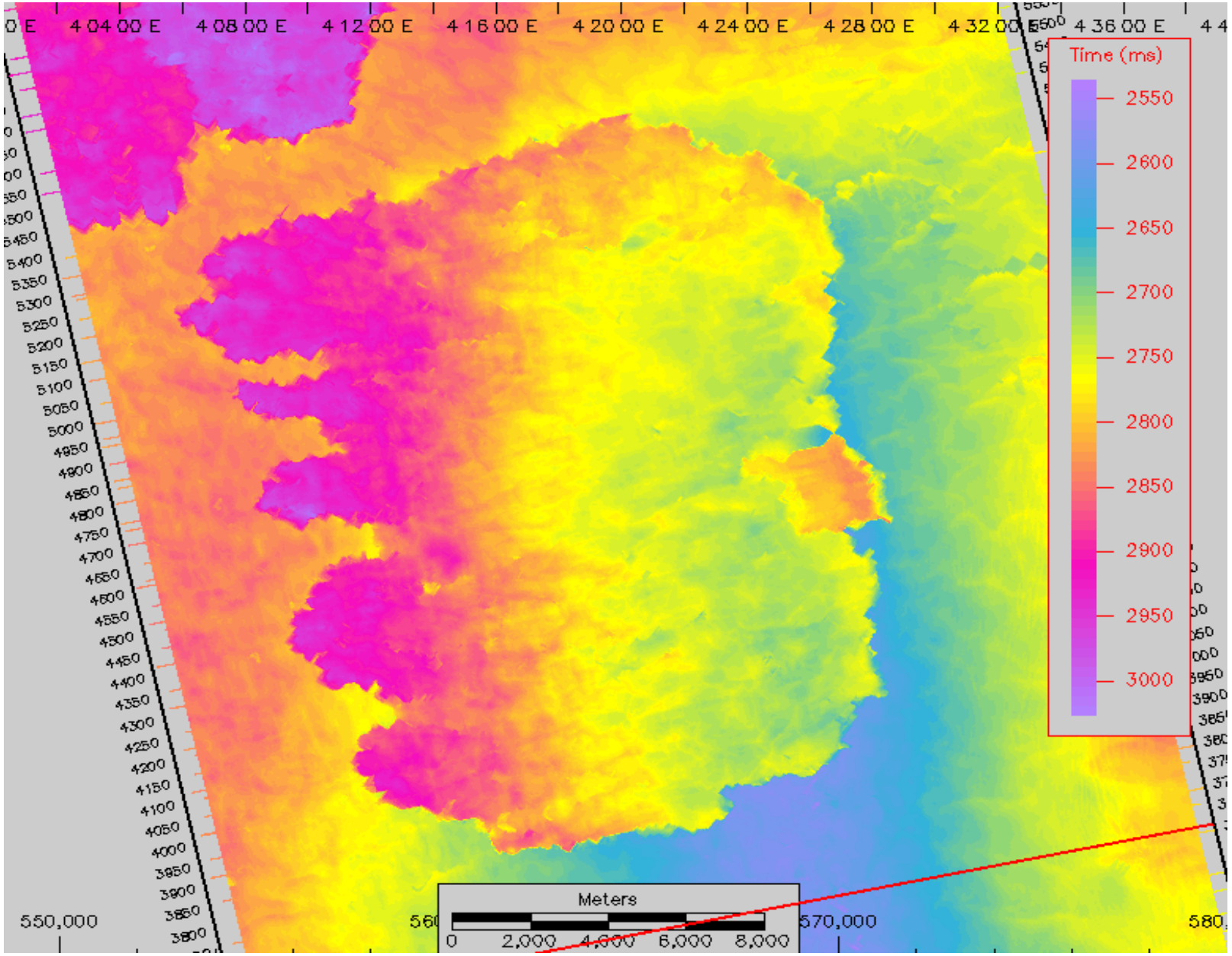

Time (ms)
2550
2600
2650
2700
2750
2800
2850
2900
2950
3000
B
A
Meters
0
5,000
10,000
15,000
20,000
550,000

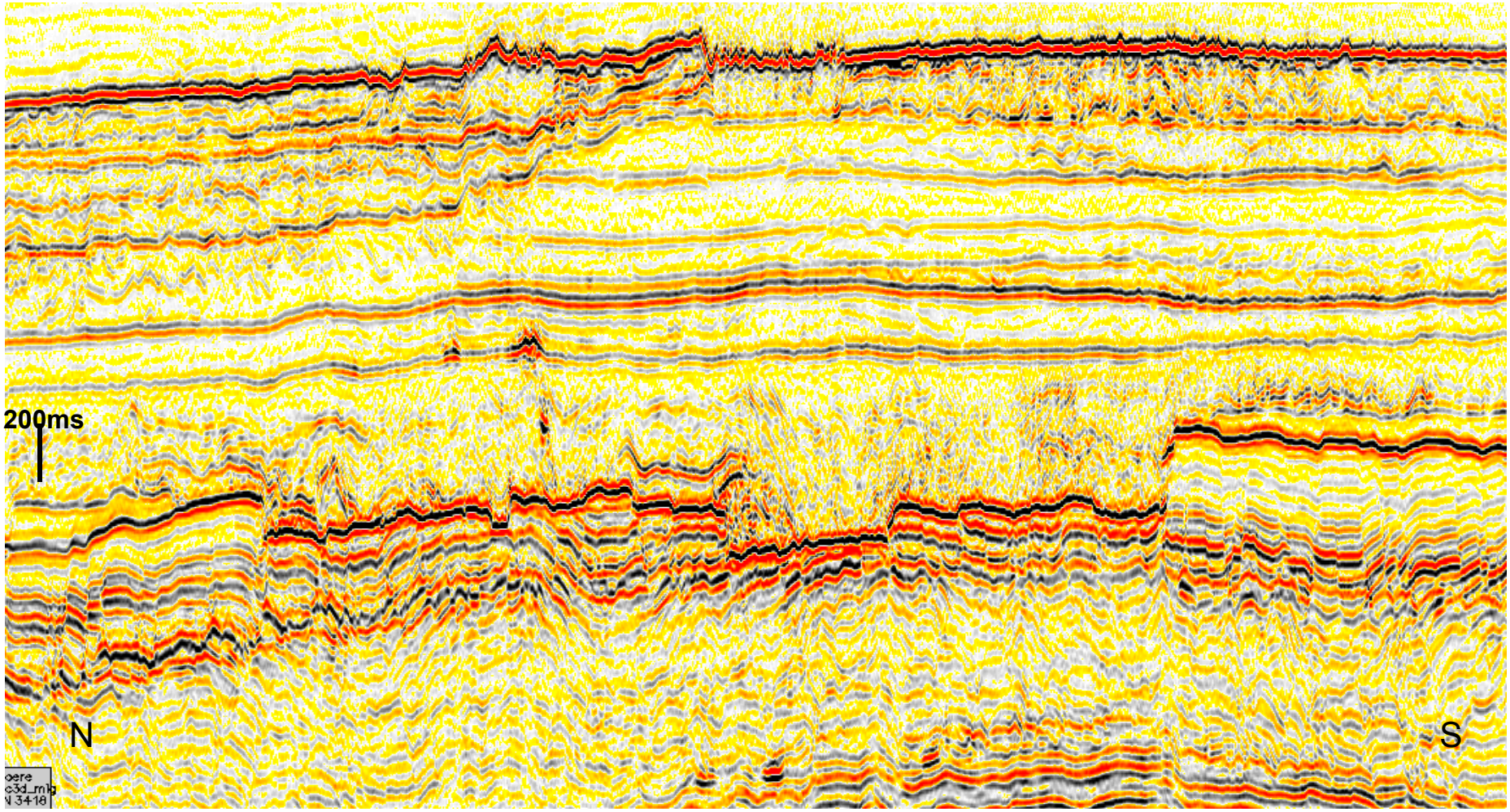


N

5km

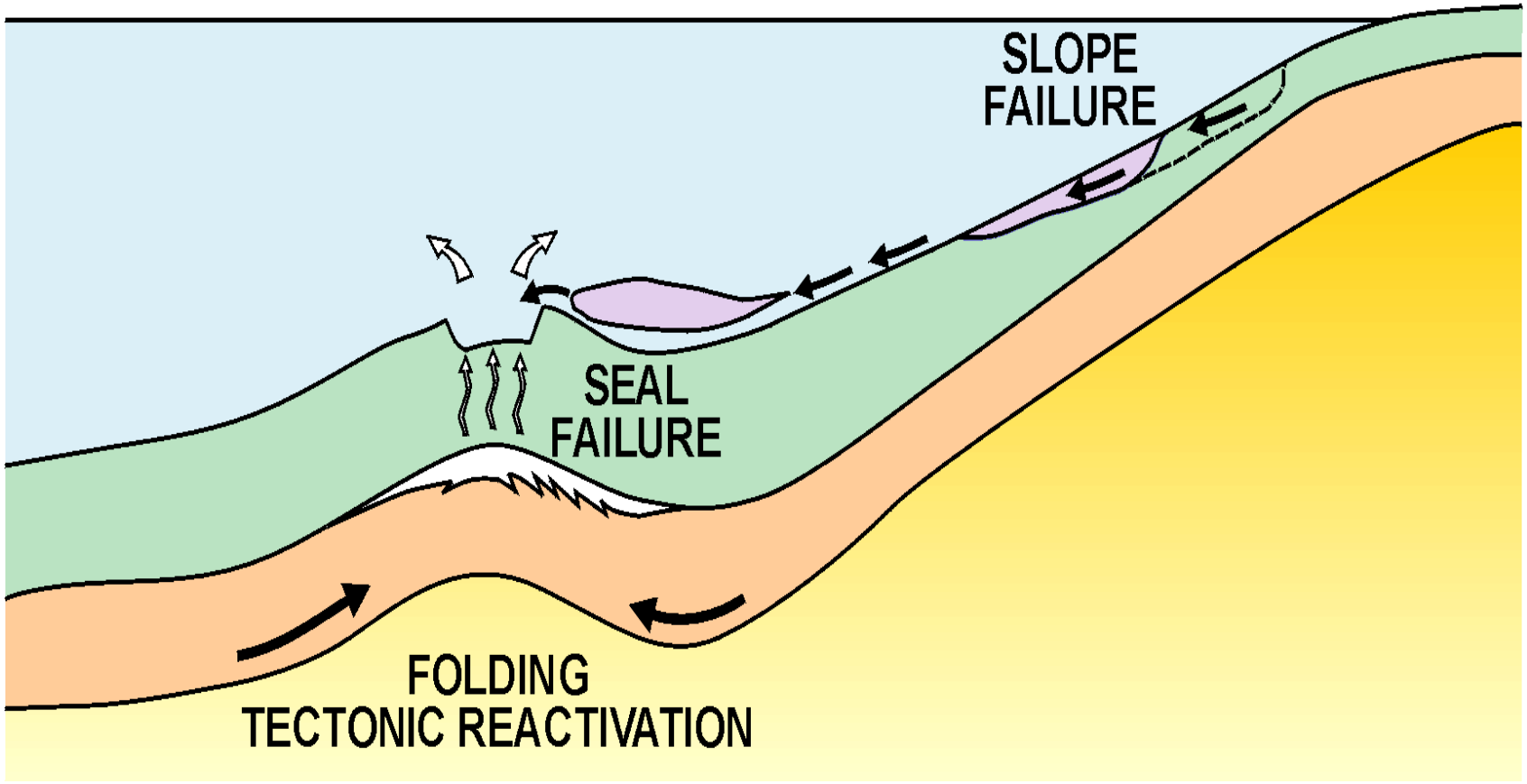
S


4 04 00 E
4 08 00 E
4 12 00 E
4 16 00 E
4 20 00 E
4 24 00 E
4 28 00 E
4 32 00
4 36 00 E
Time (ms)
2550
2600
2650
2700
2750
2800
2850
2900
2950
3000
Meters
0
2,000
4,000
6,000
8,000
550,000
570,000

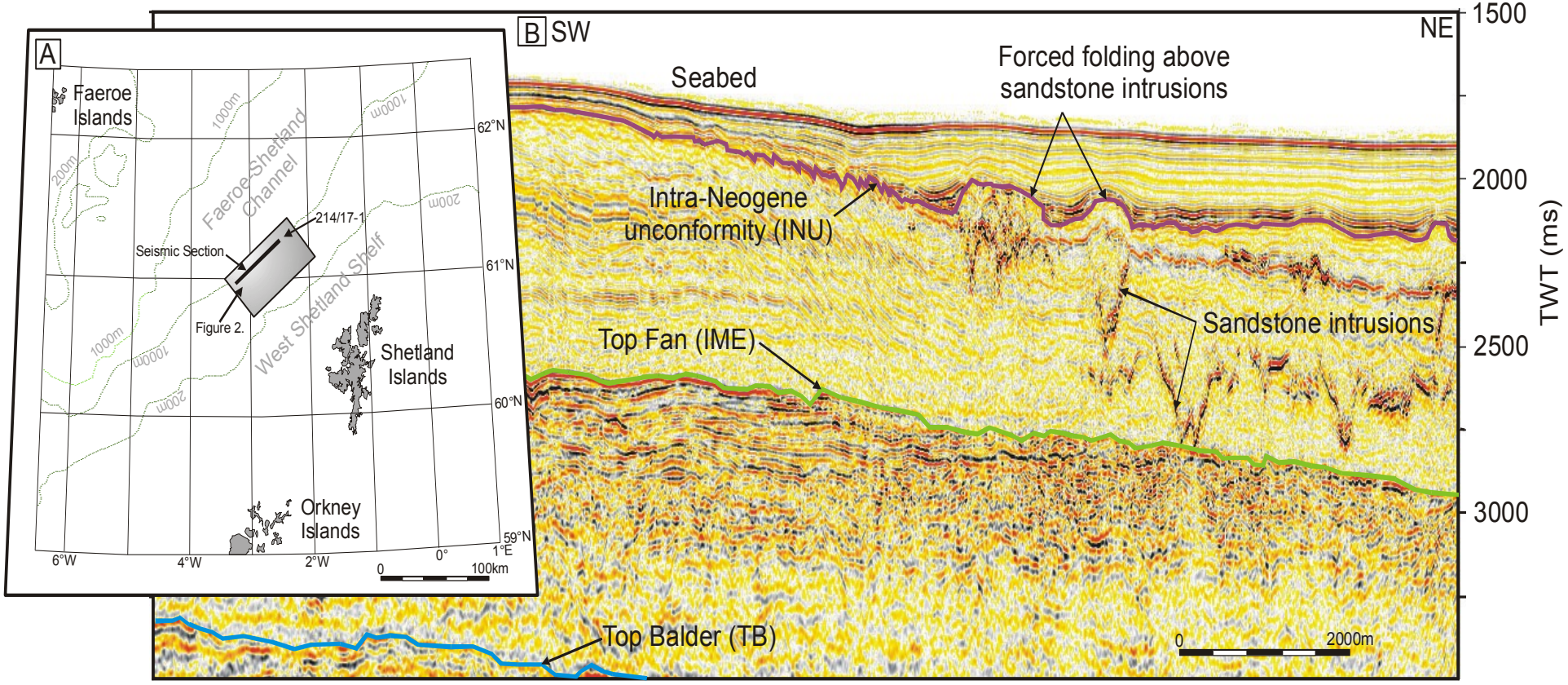


10km

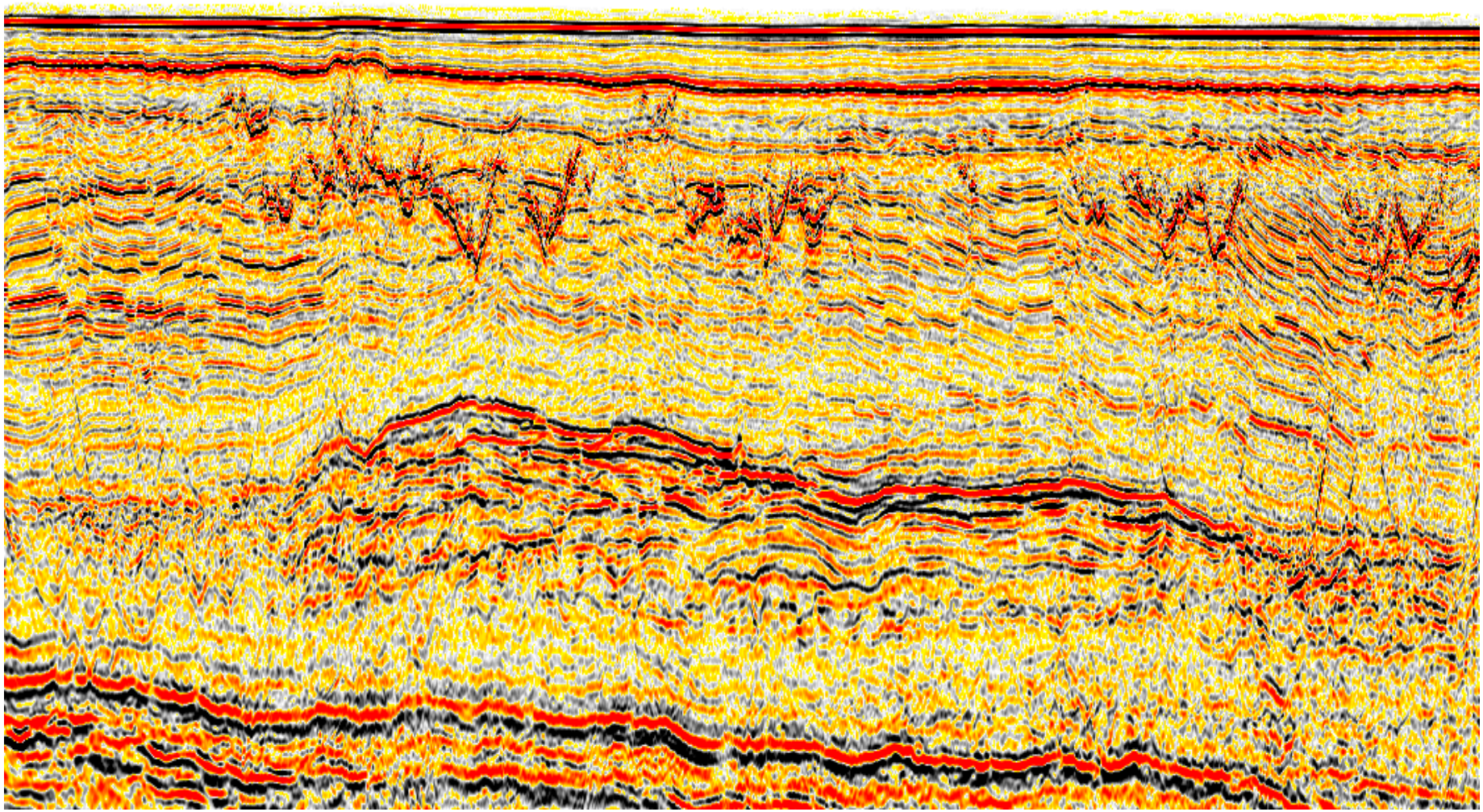
UNDERMINING OF SLOPE BY BASE-OF-SLOPE CRATER DEVELOPMENT



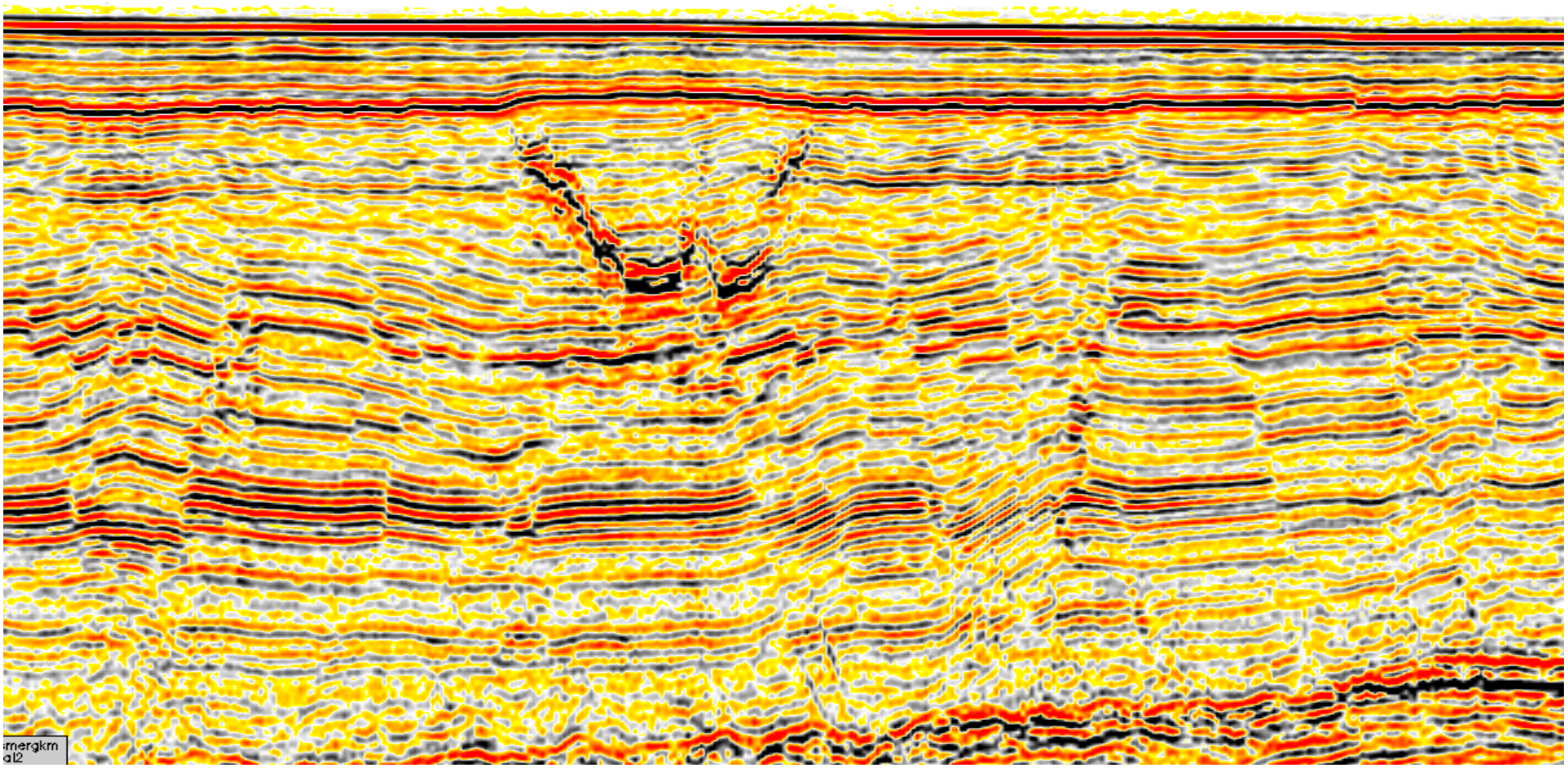
Shoulders and Cartwright Figure 1.



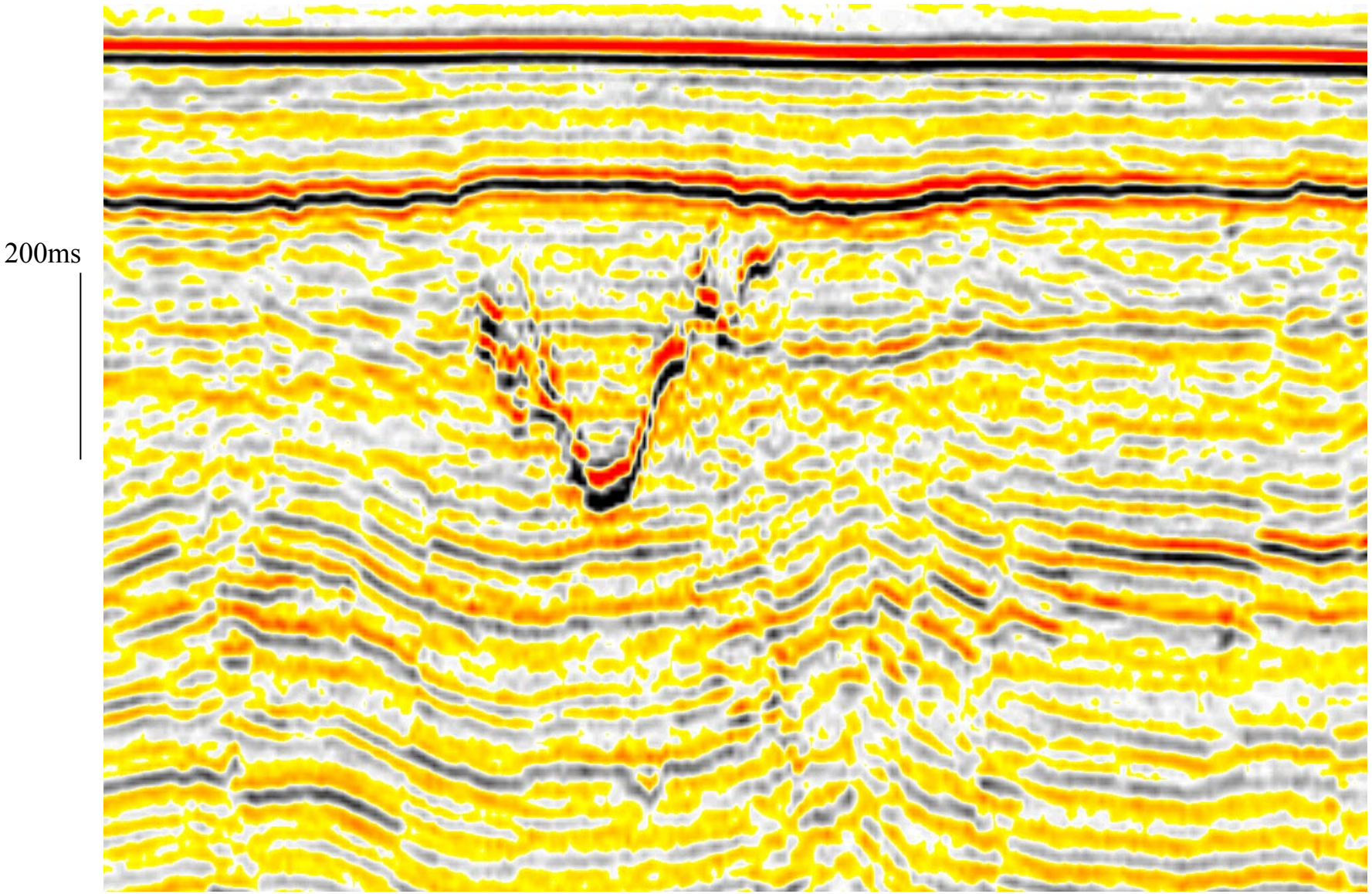
500ms

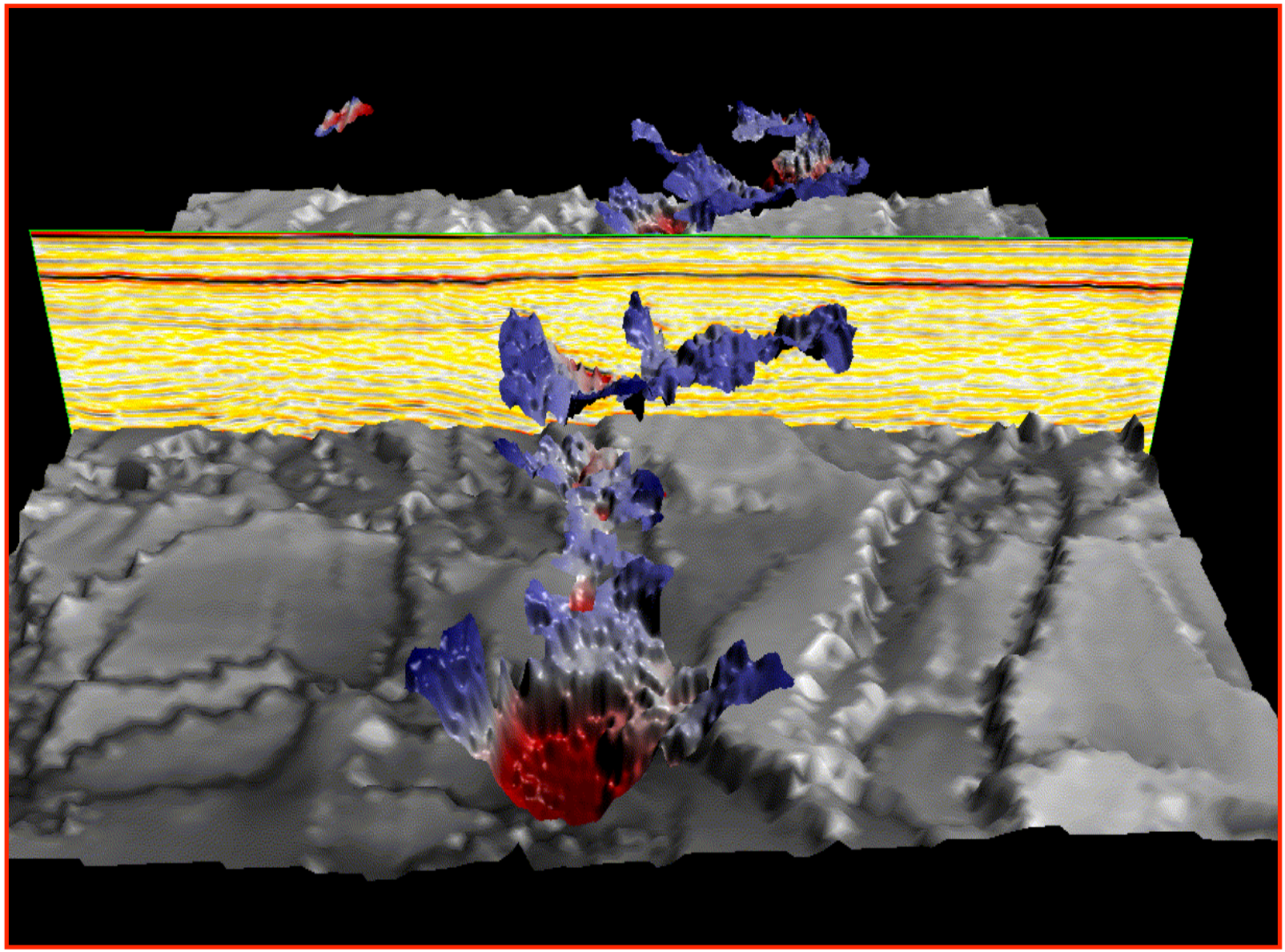


5km



2km


200ms
1000m



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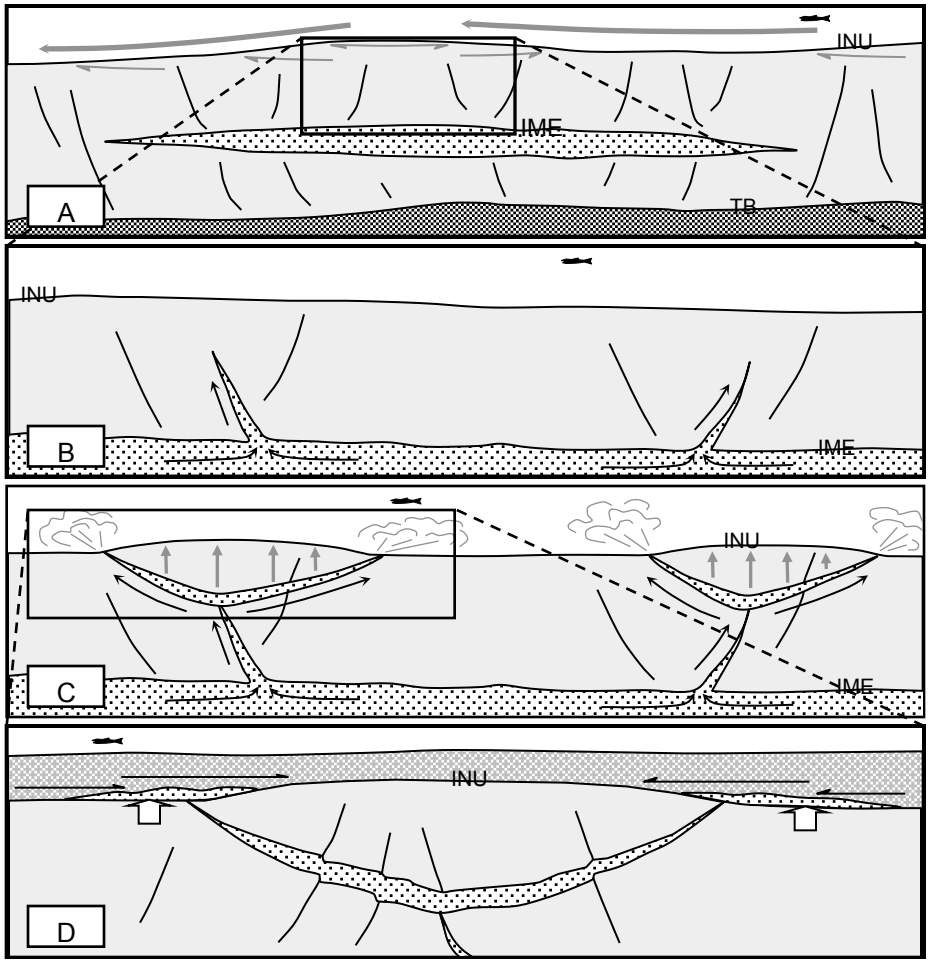
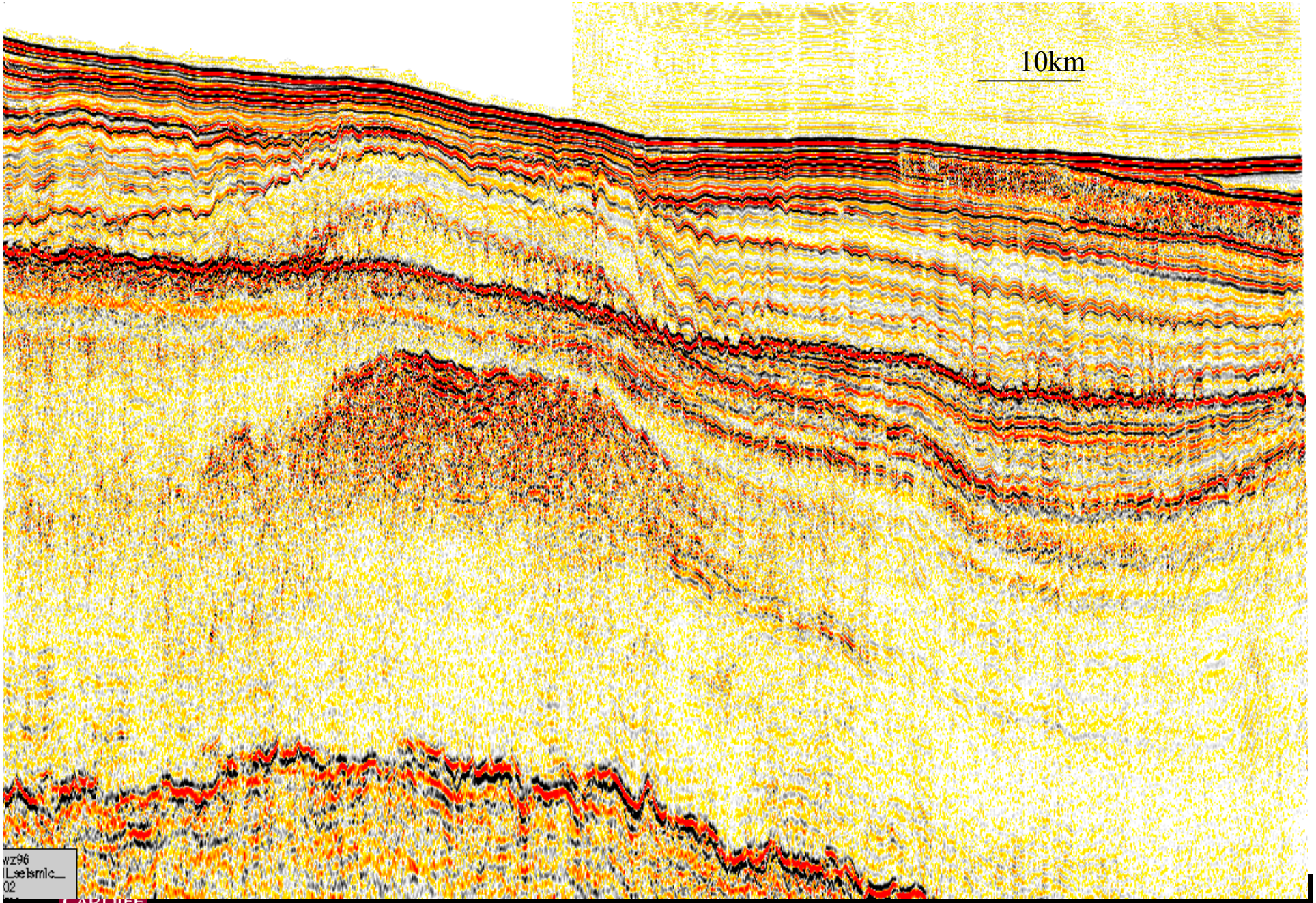
Shoulders and Cartwright (2004).



Odds and Ends



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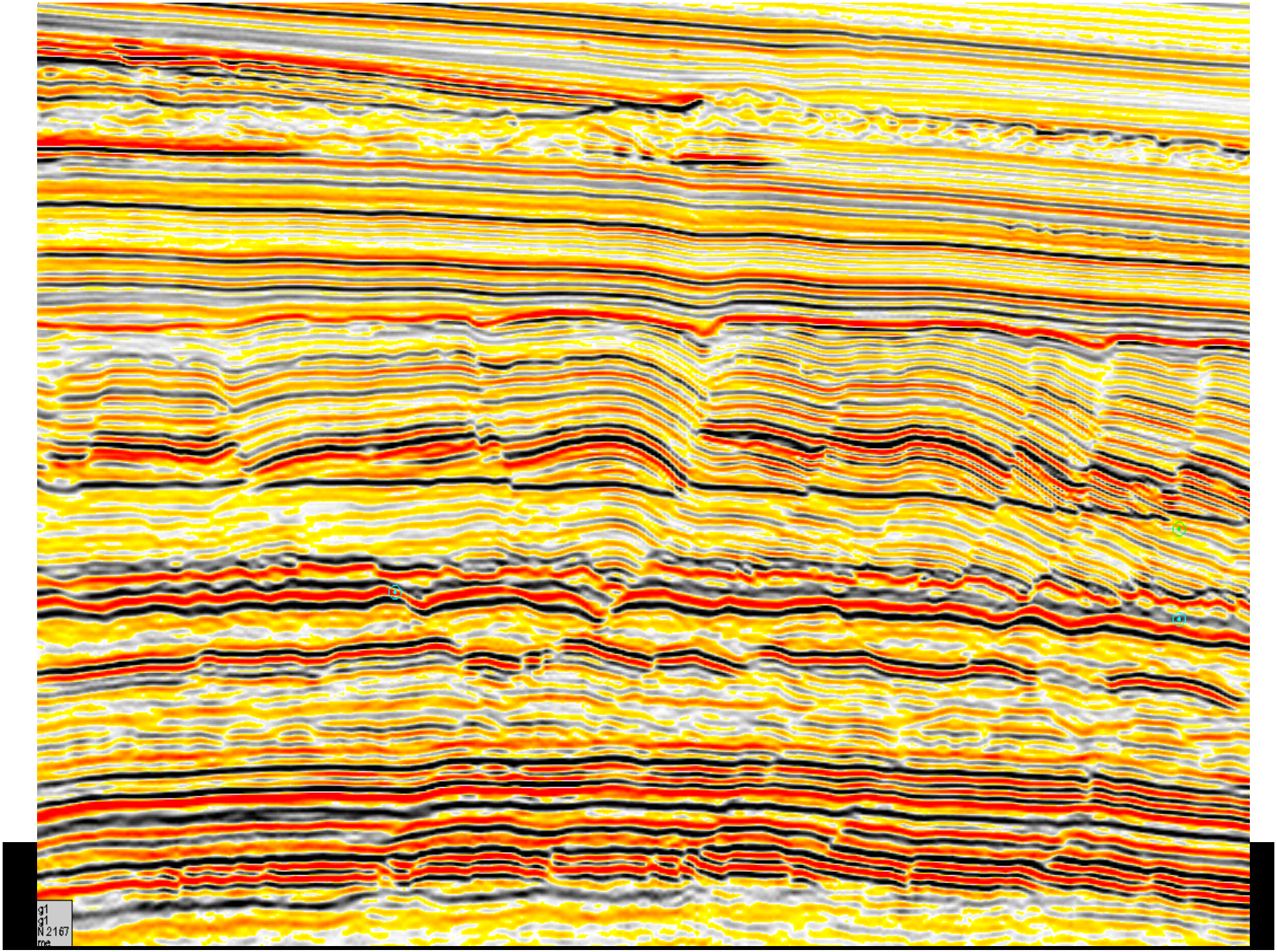
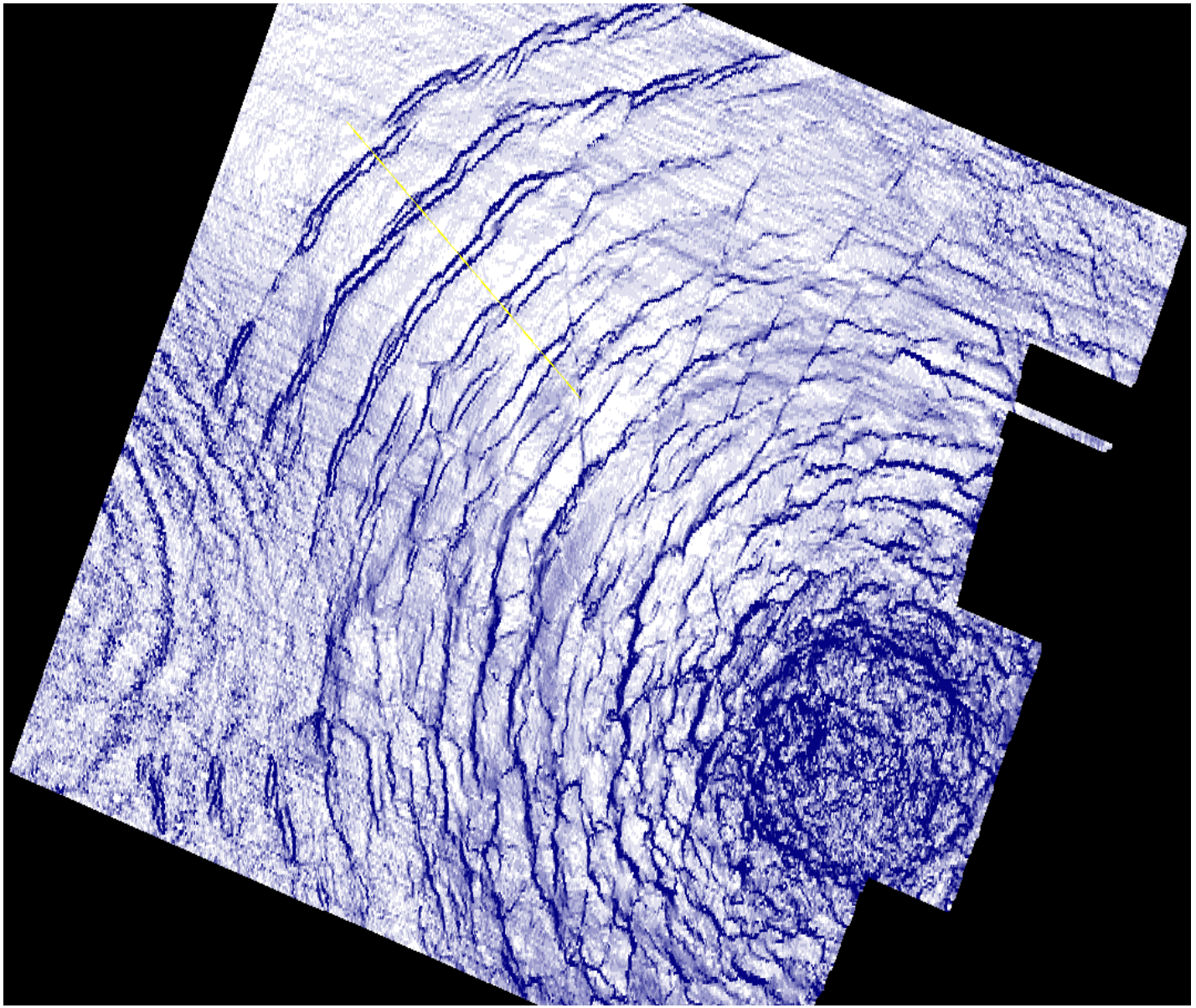

g1
g1
N 2167

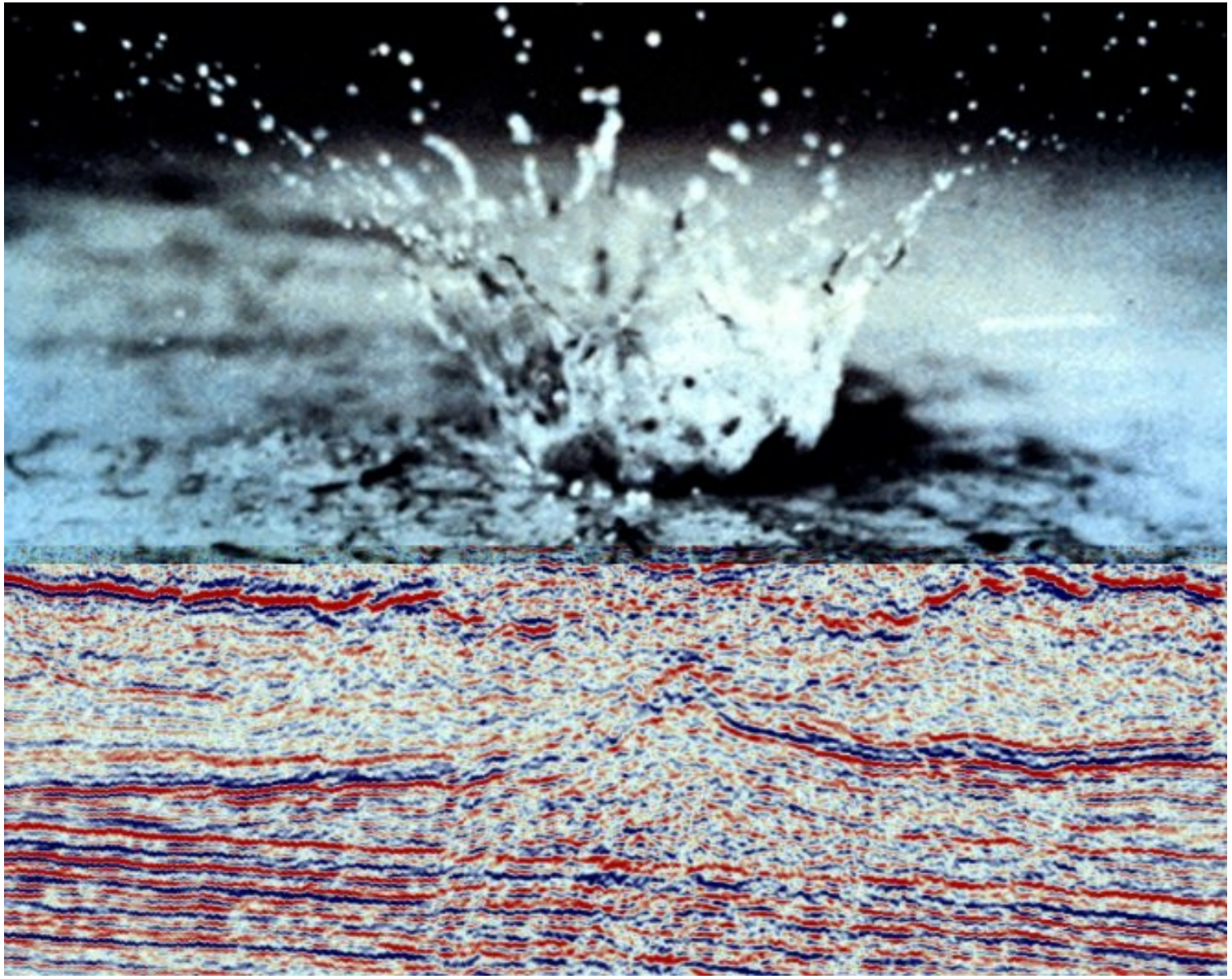
Steep dip

Low dip



Stewart and Allen,
Nature, 2002

3km



1km

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CONCLUDING REMARKS

3D seismic could (and should) revolutionise research and teaching in the geosciences

The resolving power of the 3D data is the key to gaining new insights into deformational, depositional and igneous processes

Greatest opportunity for exploratory research since early-mid 20th C field geological mapping

Much discovered already, but much more to come…….