Integrated Geophysical Imagining Techniques for Detecting Neotectonic Deformation in the Fluorspar Area Fault Complex of Western Kentucky

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Abstract 137954

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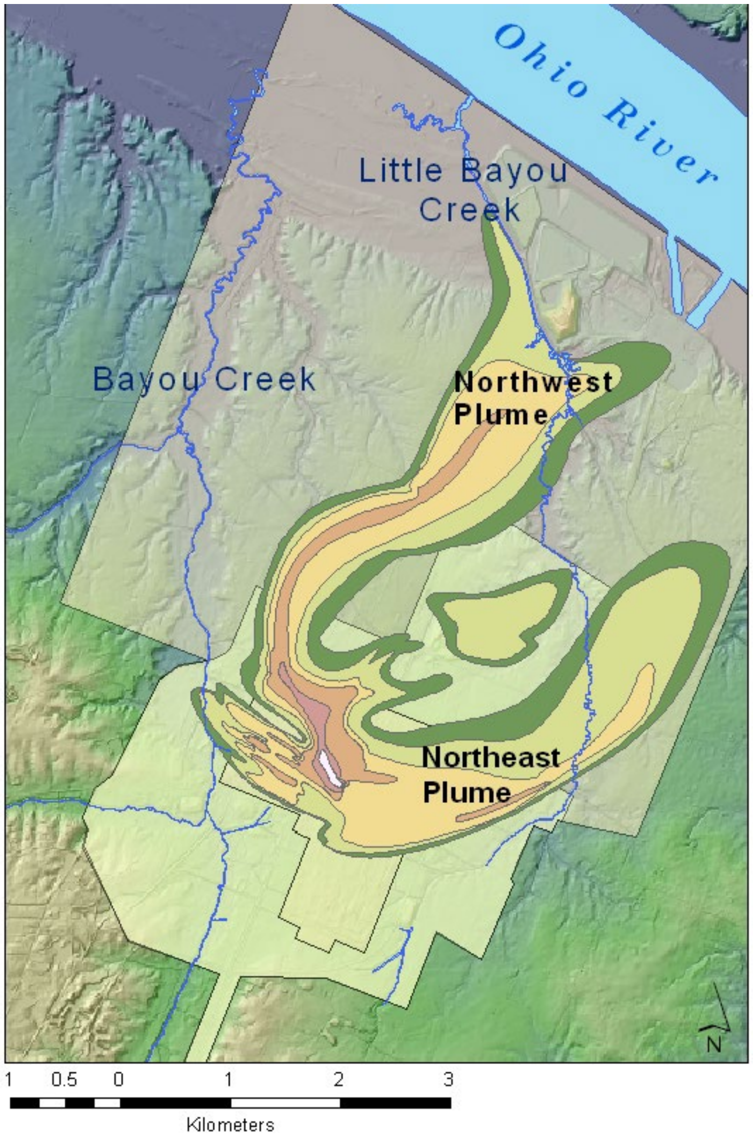
Problem

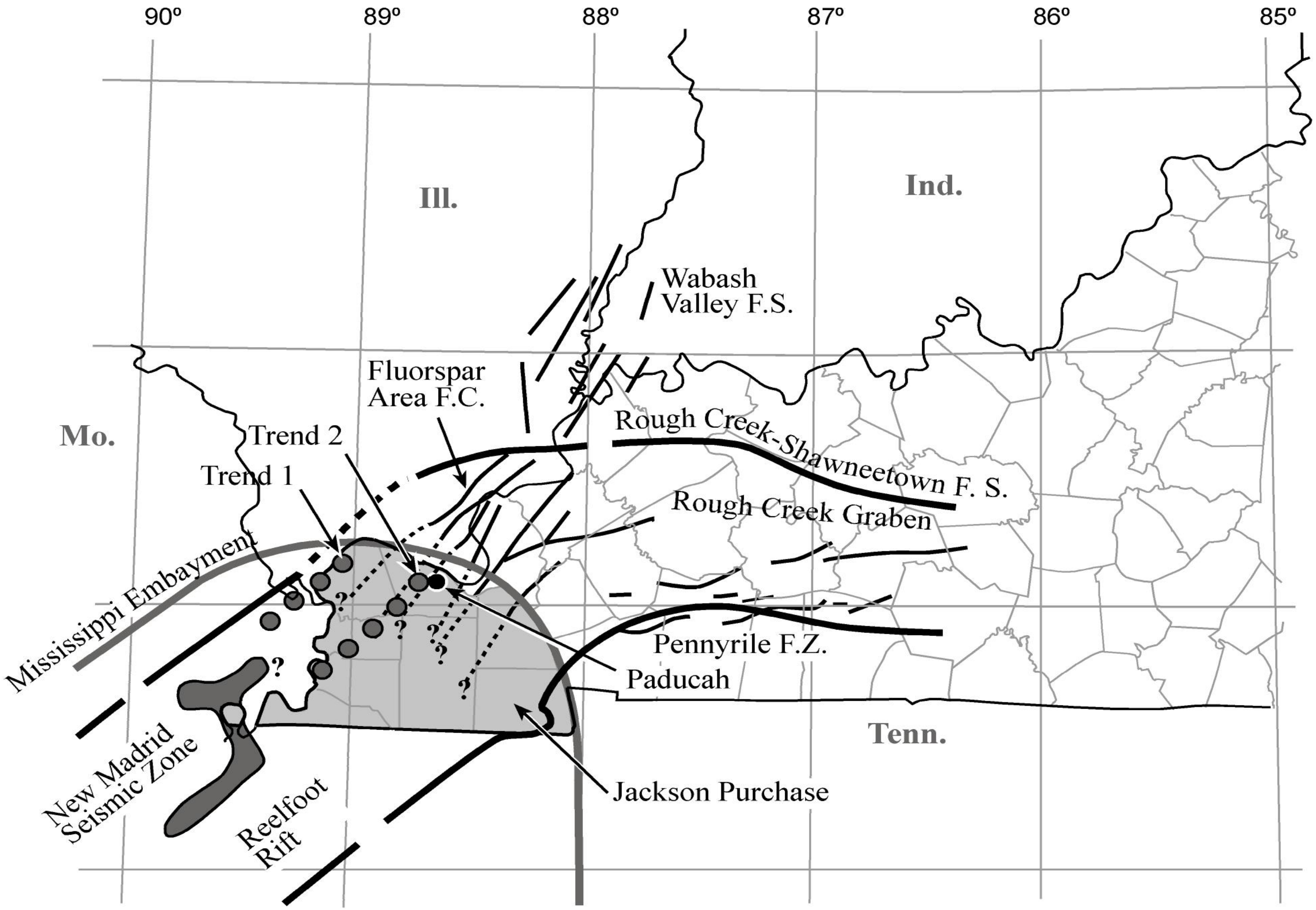


- Accurate identification and characterization of neotectonic structure in western Kentucky has proved problematic
- Lack of surface expression due to long earthquake recurrence intervals and weak sediment
- Neotectonic structure may be influencing subsurface migration of a contaminant plume west of Paducah, KY

Objectives

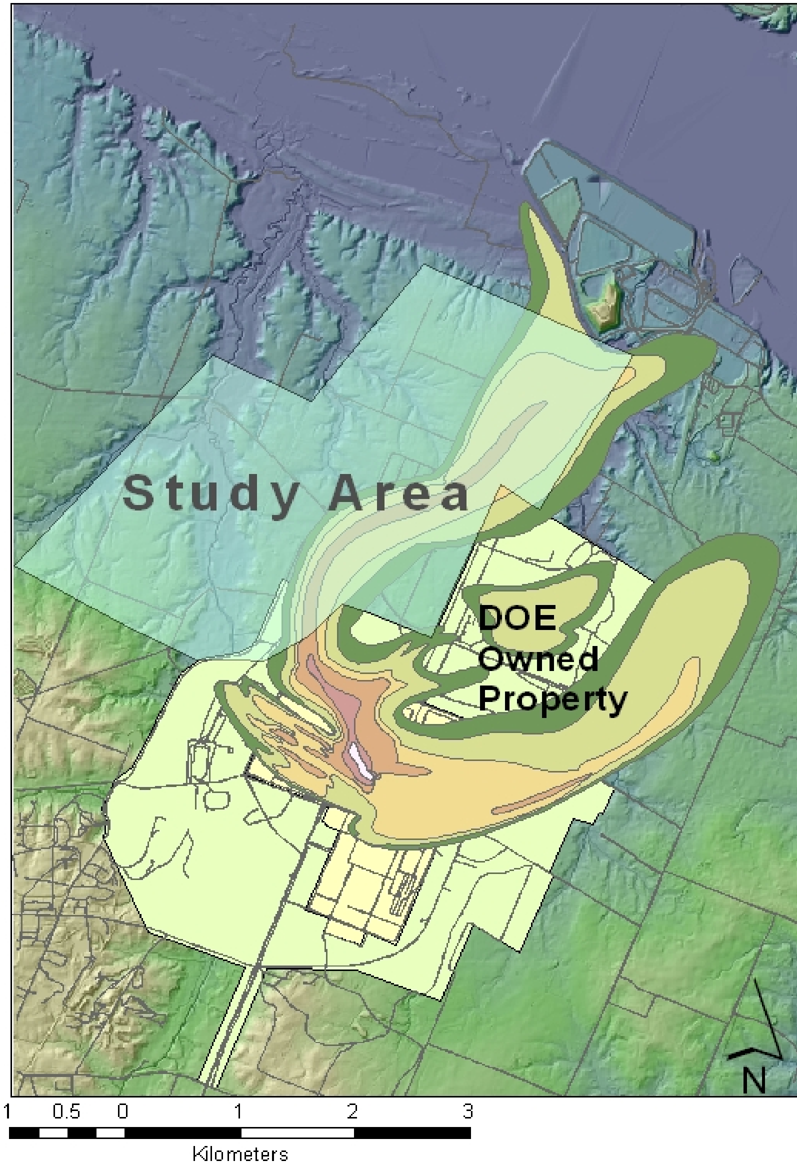
- Characterize the geologic framework so an effective groundwater contamination assessment and mitigation can be formulated.
- Non-invasive integrated geophysical methods were used to image post-Paleozoic geologic configuration across the northwest contaminant plume.

Regional Geology



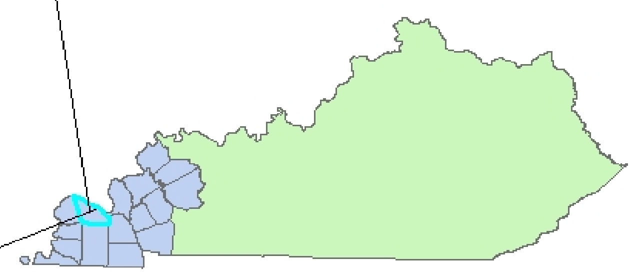
(modified from Kolata and Nelson, 1997)

Study Area



- Located approximately 16 km west of Paducah in McCracken County, western Kentucky.

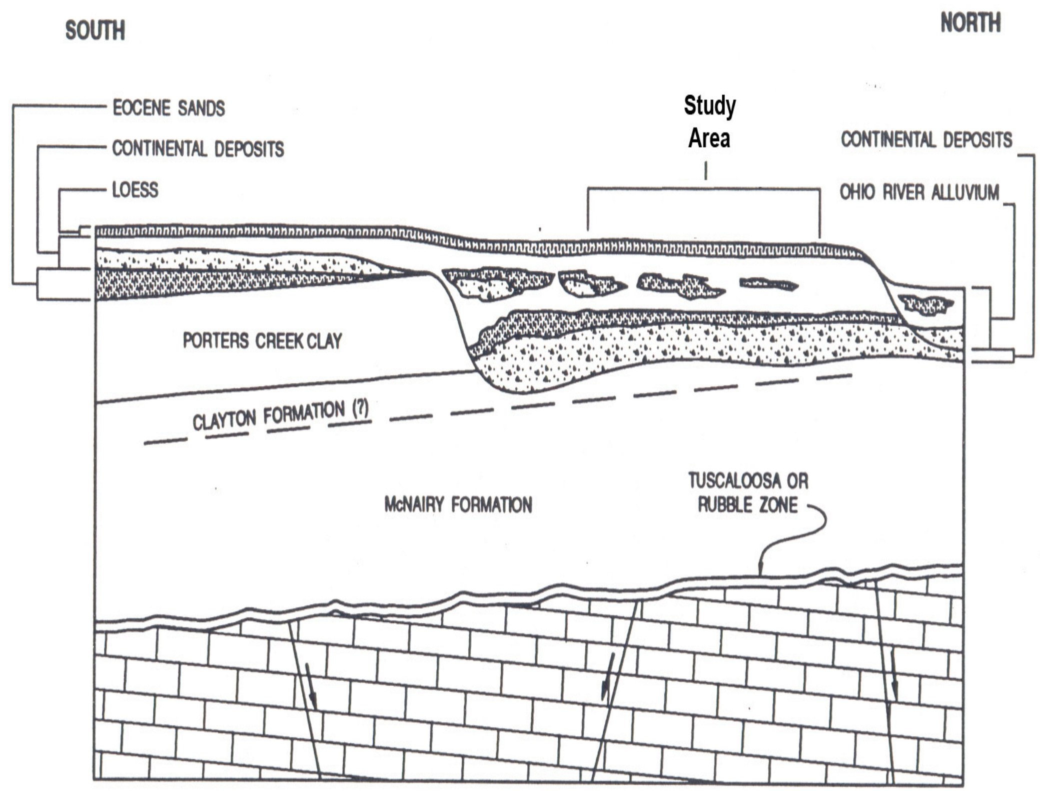
- Begins immediately north of the Paducah Gaseous Diffusion Plant and continues to within 1 km of the Ohio River.



General Geology and Stratigraphy

SYSTEM	SERIES	FORMATION	LITHOLOGY
Quaternary	HOLOCENE & PLEISTOCENE	Alluvium	
	PLEISTOCENE	Peoria Loess	
		Roxana Silt	
		Loveland Silt	
	PLEISTOCENE	Metropolis	
Tertiary	PLIOCENE-MIOCENE (?)	Mounds Gravel	
	EOCENE	Jackson, Claiborn, and Wilcox Formations	
	PALEOCENE	Porters Creek Clay	
		Clayton Formation	
UPPER CRETACEOUS		McNairy Formation	
		Rubble Zone	
MISSISSIPPIAN		Mississippian Carbonates	

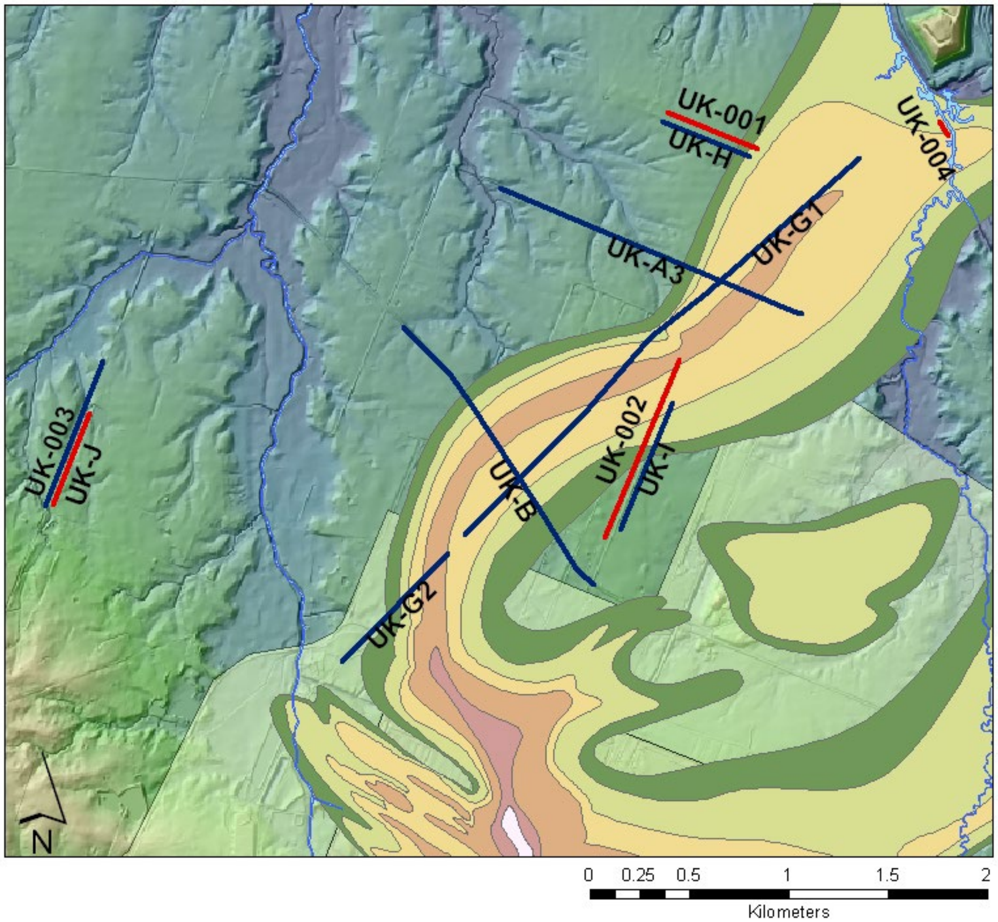
Missing



(Modified from Clausen et al., 1992)

Methodology

1) SH-wave seismic reflection surveys
2) Dipole-dipole electrical resistivity arrays



Data Acquisition

Seismic Reflection Acquisition Parameters										
Line Name	Suvey Type	Near Offset	Shot Interval	Geophone Spacing	Sample Interval (ms)	Record Length (s)	Acq. Filt. - Low Cut (Hz)	Acq. Filt. - Hi Cut (Hz)	Notch Filter (60 Hz)	Geophone (Hz)
UK-A3[1]	SH-wave	0m	4m	4m	0.5	1.00	10	250	Yes	30
UK-B[1]	SH-wave	0m	4m	4m	0.5	1.00	10	250	Yes	30
UK-G1[1]	SH-wave	0m	4m	4m	0.5	1.00	10	250	Yes	30
UK-G2[1]	SH-wave	0m	4m	4m	0.5	1.00	10	250	Yes	30
UK-H	SH-wave	2m	2m	2m	0.25	1.024	15	Out	No	30
UK-I	SH-wave	4m	4m	4m	0.25	1.024	15	Out	No	30
UK-J[2]	SH-wave	2m	2m	2m	0.25	1.024	15	Out	Yes	30

1: Collected by Langston and Street (1997)
2: Collected by Wood, McDowell, Woolery and Wang (2000-2001)

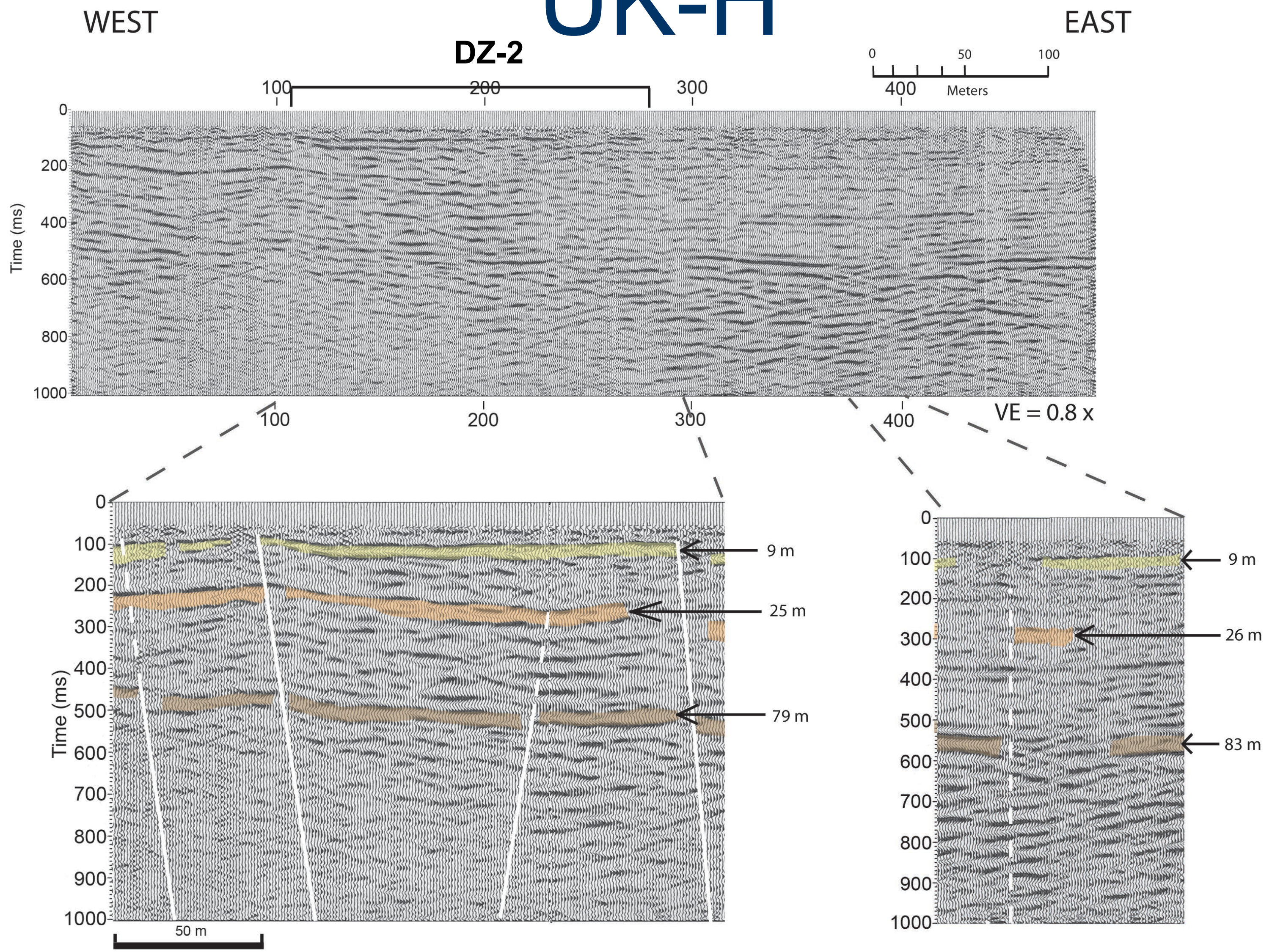
Electrical Resistivity Imaging Acquisition Parameters									
Line Name	Array Type	Electrode Spacing (m)	Maximum n	Maximum Dipole	Measure Time (s)	Cycles	Maximum Error (%)	Maximum Repeat	Maximum Current (mA)
UK-001	Dipole-Dipole	6	8	6	1.2	2	2.0	1	2000
UK-002	Dipole-Dipole	6	8	6	1.2	2	2.0	1	2000
UK-003	Dipole-Dipole	6	8	6	1.2	2	2.0	1	2000
UK-004	Dipole-Dipole	2	8	6	1.2	2	2.0	1	2000

Processing

Generalized Steps for Processing Seismic Reflection Data	
Processing Step	**Comment**
Reformat Data	Convert from DAT format to standard SEG-Y format
Extract Data	Create file containing data from optimum window
Exponential Gain Recovery	Correct for spherical divergence
Mean Amplitude Scaling	Equalize traces
Bandpass Filter	Attenuate noise outside of a range of frequencies
Automatic Gain Control (AGC)	Normalize data within a given time window
Geometry	Apply acquisition geometry header to traces
Trace Kills	Remove noisy traces
Trace Mutes	Remove refractions, direct waves, and ground roll
Sort by Offset	Reorder data based into common-offset gathers
Stack by Offset	Combine sorted files
Velocity Analysis	Obtain a subsurface velocity model
Normal Moveout (NMO)	Correct for source-receiver travel time differences
Sort by CDP	Reorder data by common subsurface point
Stack by CDP	Vertically sum NMO-corrected CDP gathers
F-K Filter	Attenuate linear coherent noise

Resistivity Inversion Settings	
Number of CG iterations	6
Starting iteration of quasi Newtonian method	20
Smoothness factor	10
Damping factor	10
Estimated noise	3%
Robust data conditioner	1
Robust model conditioner	1
Minimum resistivity (Ohm·m)	1
Maximum resistivity (Ohm·m)	100000
Model parameter width	1
Model parameter height	1
Resolution factor	0.2
Stop Criteria:	
Number of iterations	8
Maximum RMS error	3%
Error reduction	5%

UK-H

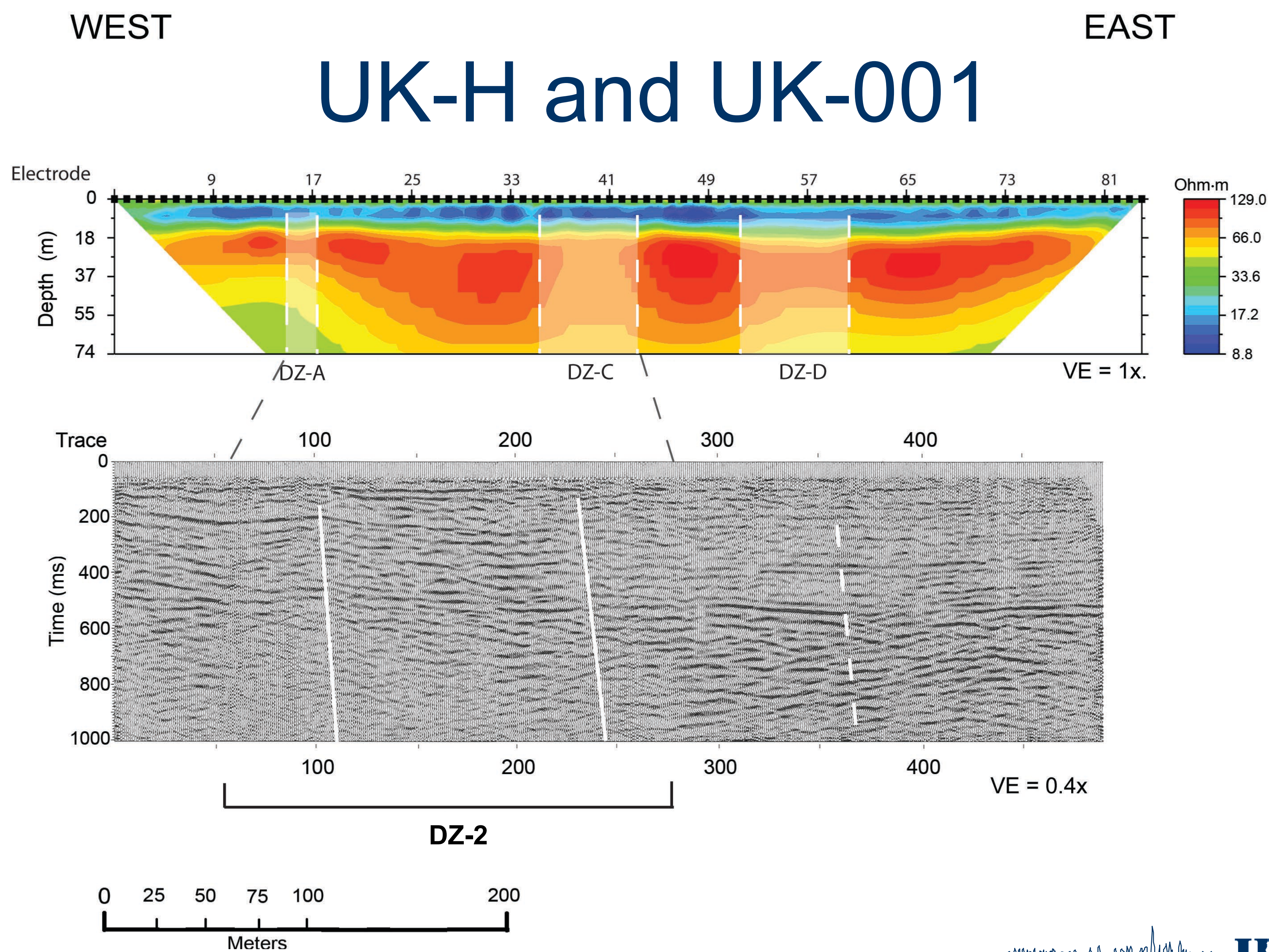


R1 Lower Continental Deposits

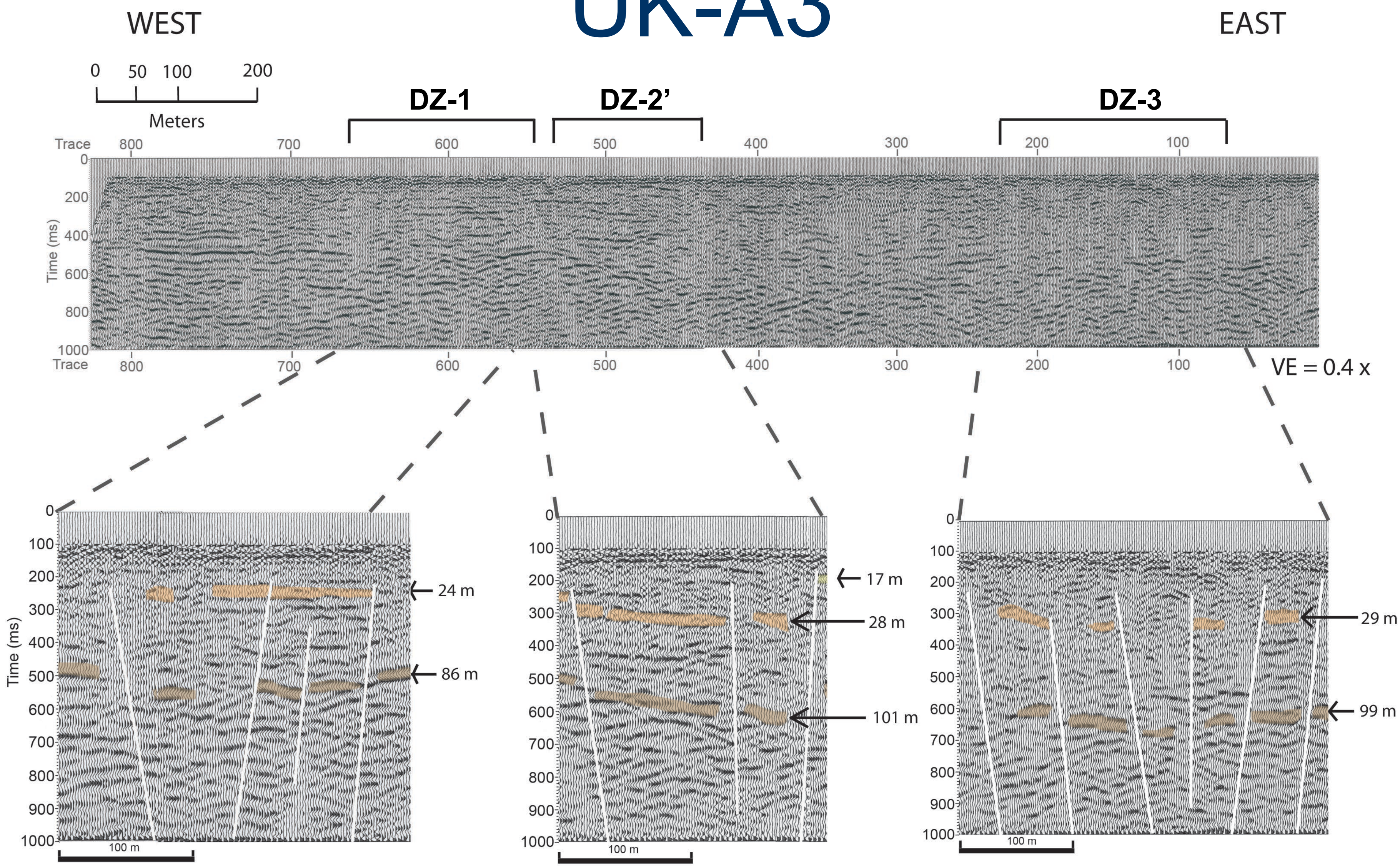
R2 McNairy Formation

R3 Paleozoic Bedrock

UK-H and UK-001

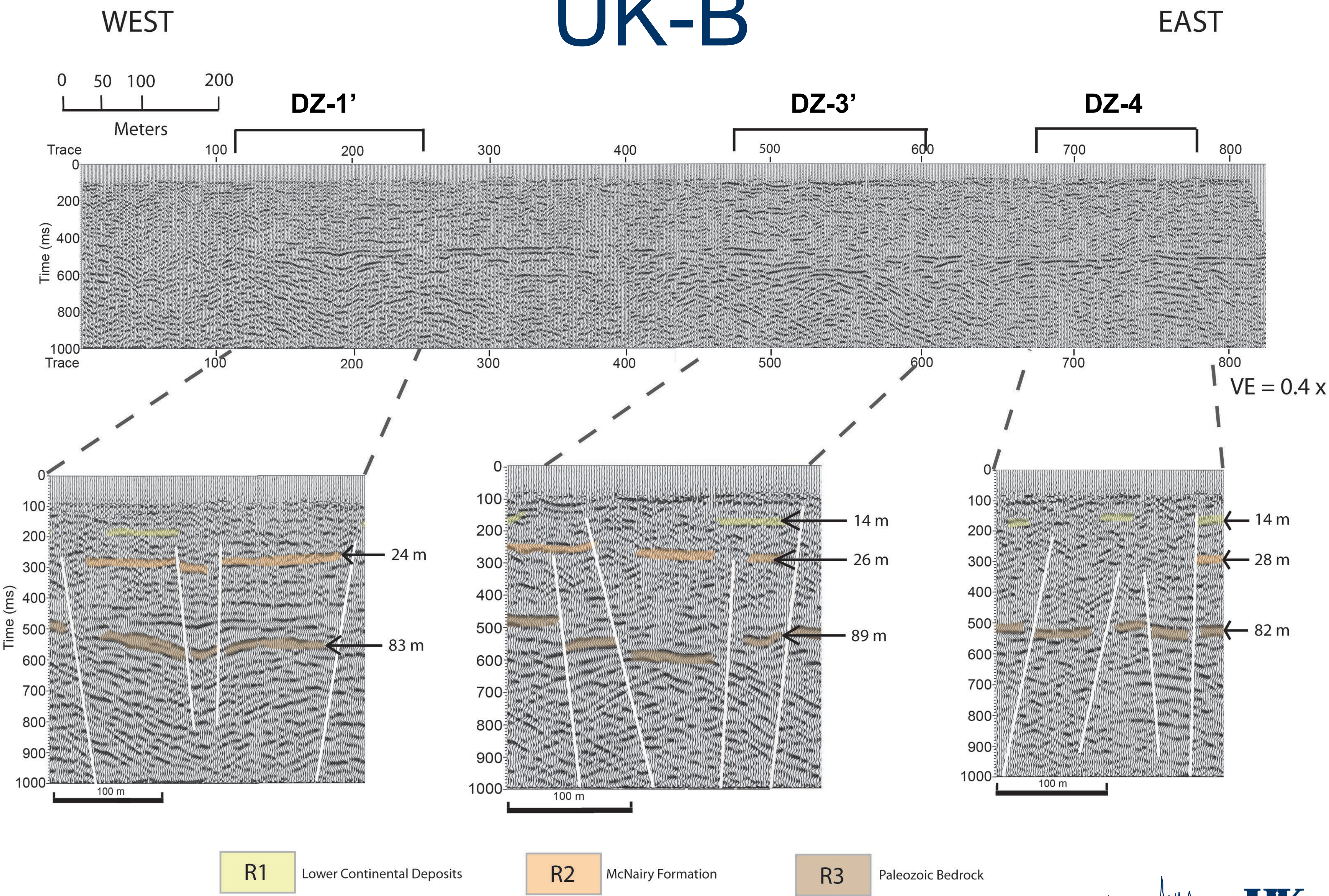


UK-A3



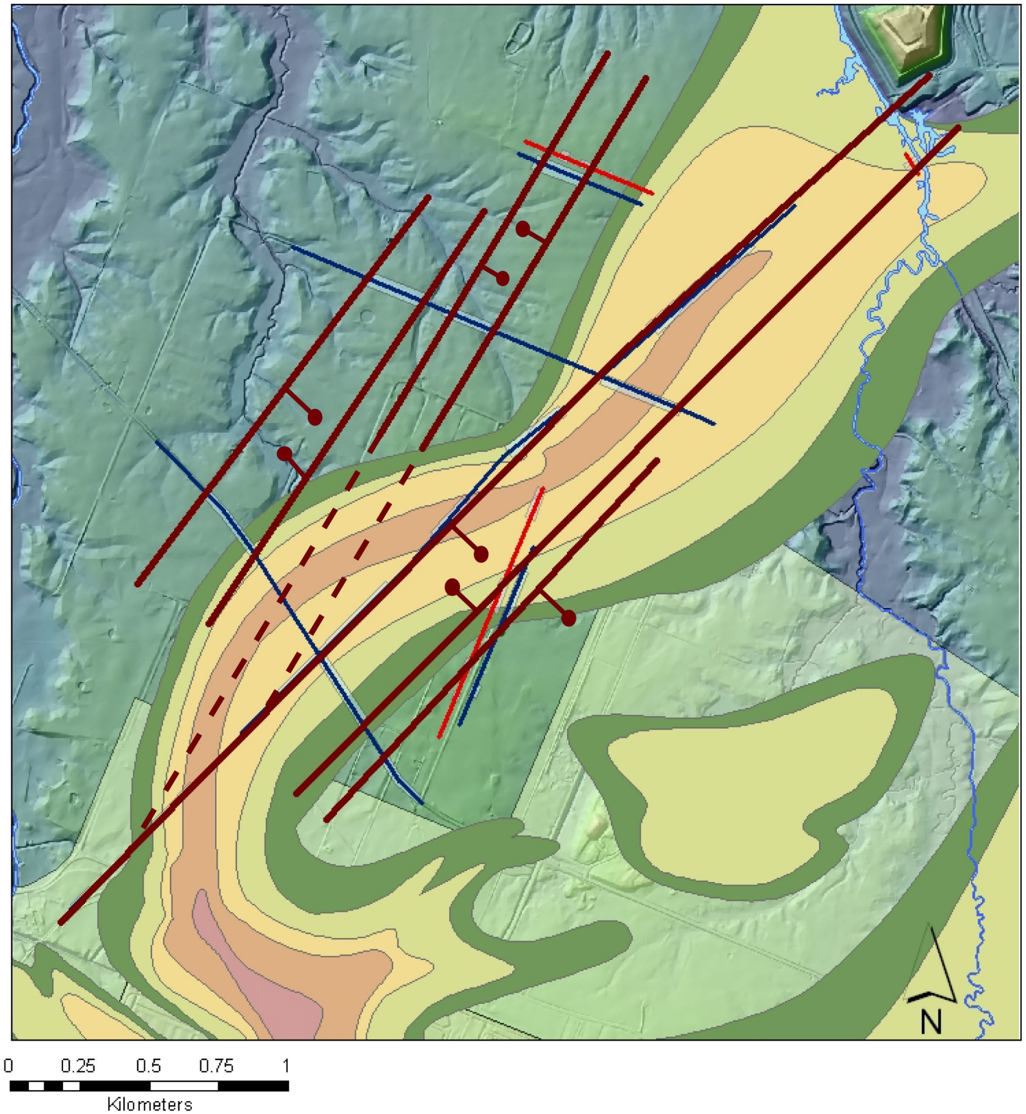
R1	Lower Continental Deposits
R2	McNairy Formation
R3	Paleozoic Bedrock

UK-B



WEST
EAST
0 50 100 200
Meters
DZ-1’
DZ-3’
DZ-4
Trace
Time (ms)
VE = 0.4 x
24 m
83 m
14 m
26 m
89 m
14 m
28 m
82 m
100 m
R1 Lower Continental Deposits
R2 McNairy Formation
R3 Paleozoic Bedrock

Interpreted Faulting



- Series of high-angle faults striking approximately N30°E to N45°E outlining a series of asymmetric grabens.
- Greater displacements are observed in the bedrock reflector than within overlying sedimentary horizons.
- Early Paleozoic faulting reactivated as recently as the Pleistocene.

General Summary

- Over 7.8-km of seismic reflection data and 2-km of electrical resistivity data were acquired, processed, and interpreted.
- Imaged high-angle faults extending into Pleistocene horizons are consistent with results from other parts of the FAFC (Nelson et al., 1997, 1999; Langston et al., 1998; Woolery and Street, 2002, etc.).
- Structural features preferentially oriented with groundwater and contaminant migration.
- Additional geophysical/geological data are needed to reduce uncertainty.

Acknowledgements

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