Direct Detection of NAPLs using GPR Velocity and Attribute Analysis

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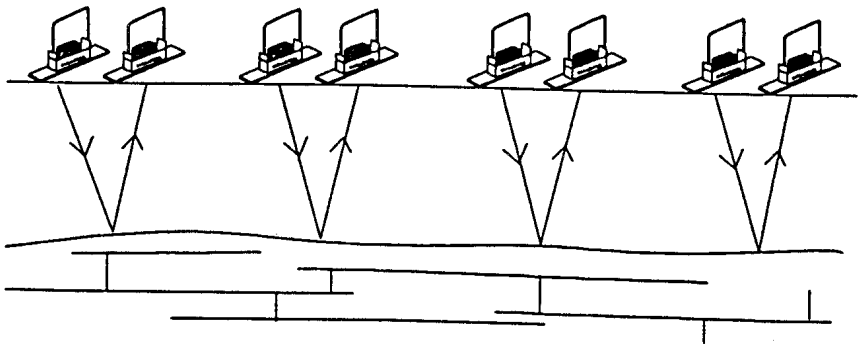
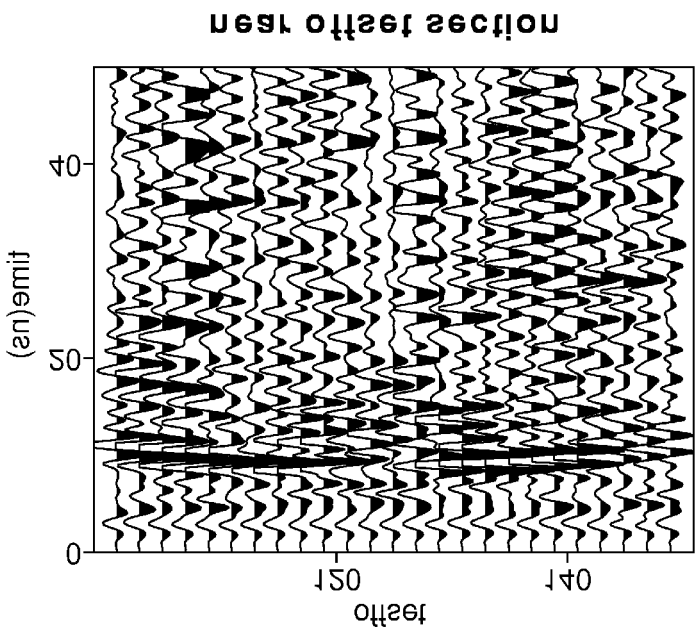
Overview

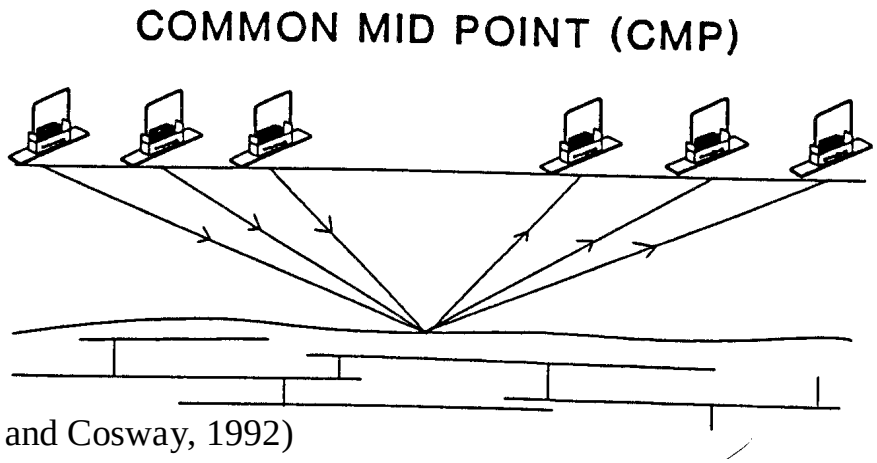
- Review of methodologies
- Integrating 3-phase flow and geophysical models
  - < Dover AFB
- Hill AFB
- Savannah River Site

Common Offset Acquisition

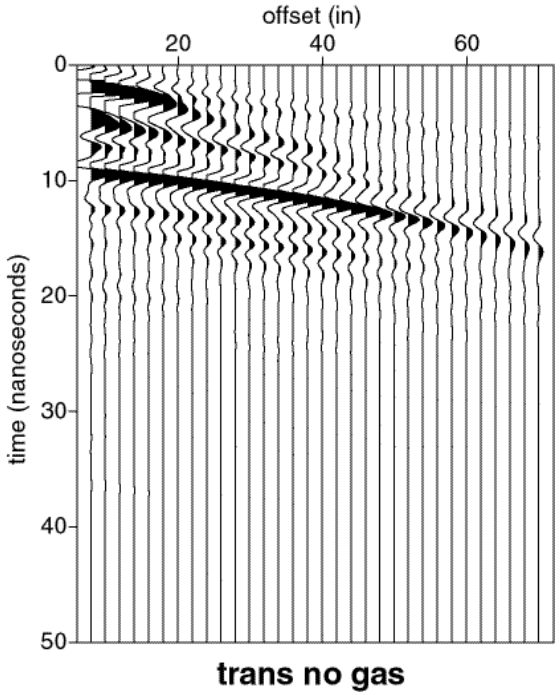


(From: Annan and Cosway, 1992)





(From: Annan and Cosway, 1992)

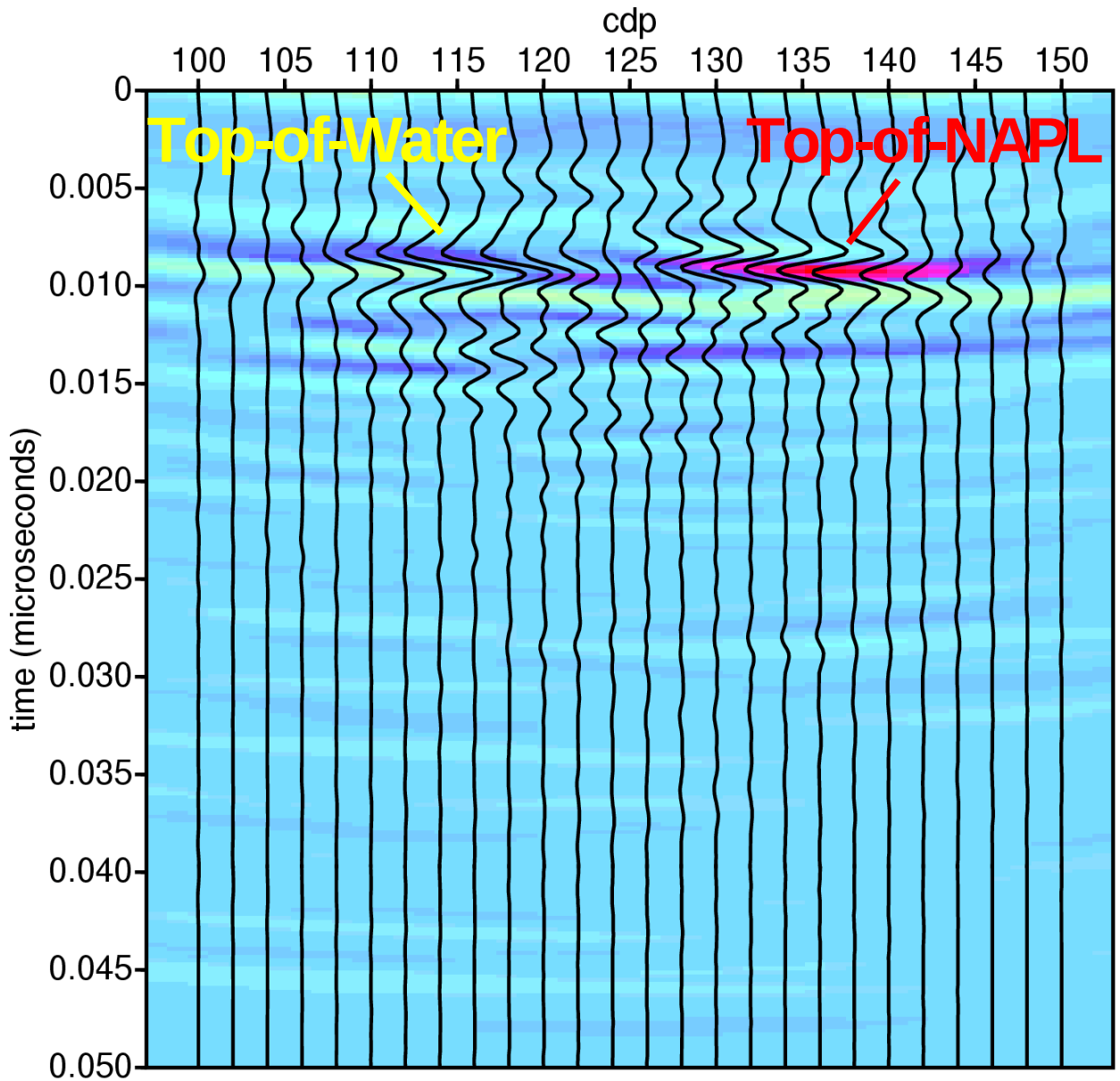


P Multi-offset acquisition

- < Detailed velocity estimates
  - – More accurate characterization of the subsurface
  - – Estimate material properties
- < Improved signal to noise through stacking

Expected Contaminant Signatures

- Increased propagation velocity
- Anomalous amplitude response
- Decreased signal attenuation

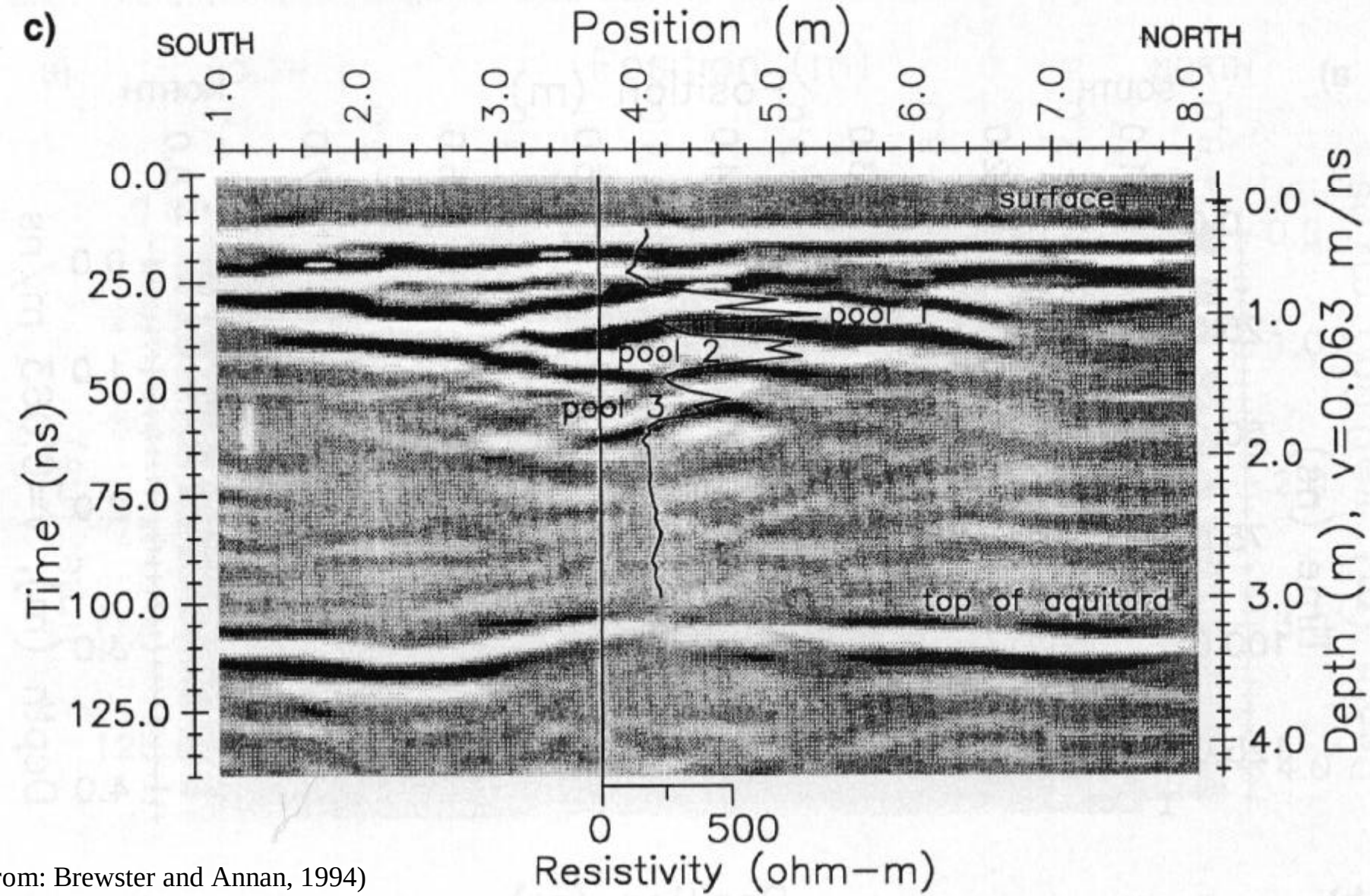


AVO Gradient Image w/ Wiggle Trace Overlay

Project Objectives

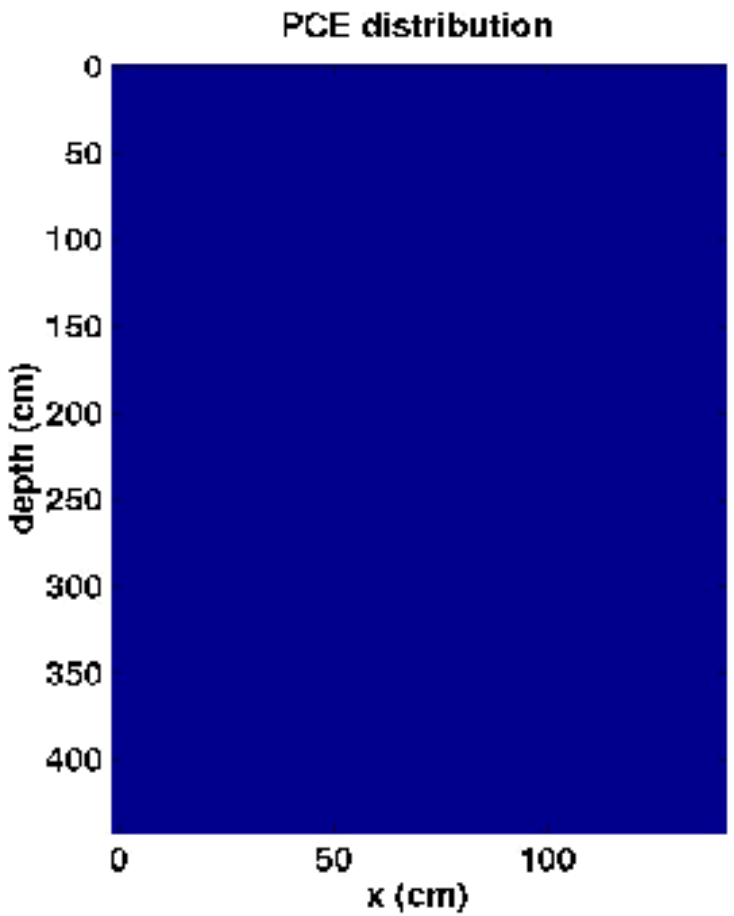
- Combine imaging and velocity analysis with quantitative attribute analysis
- Field based study in a variety of hydrogeologic settings
  - What signal attributes are the most reliable contaminant indicators?
  - How consistently can DNAPL be detected and what is the detection threshold?
- Forward modeling software
- Attribute analysis software

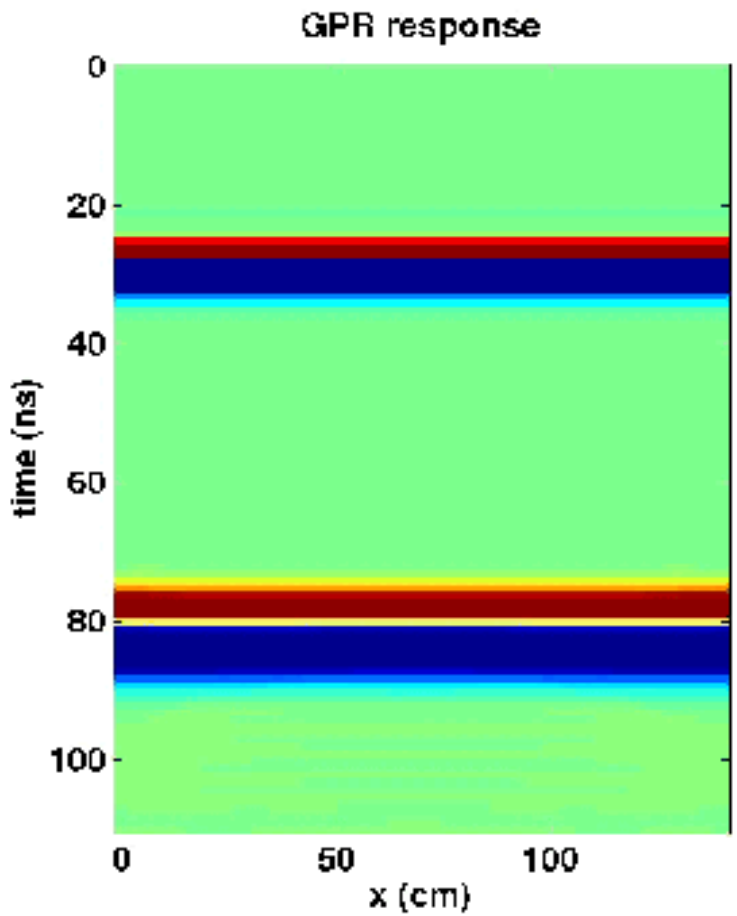
Field Locations

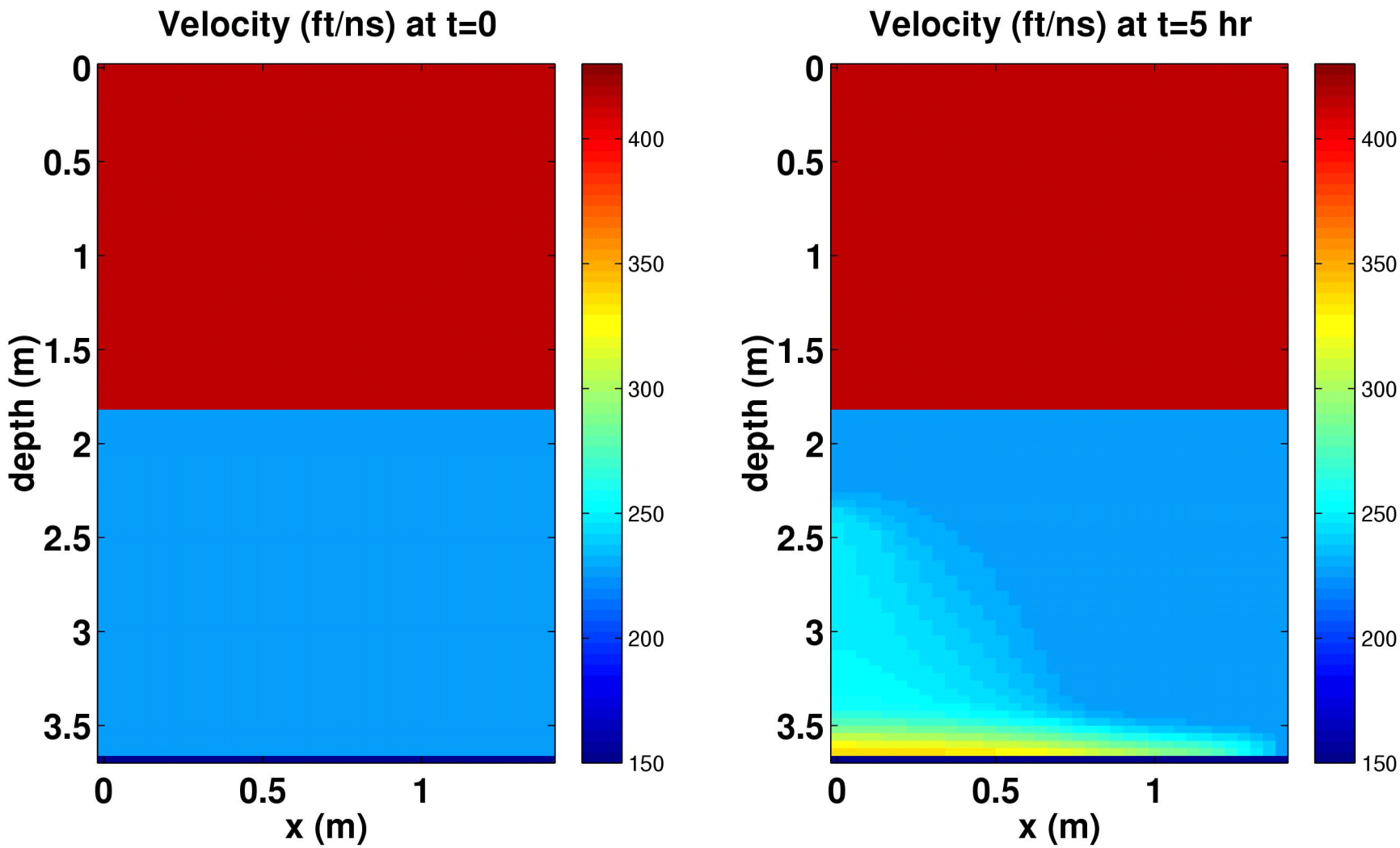


(From: Brewster and Annan, 1994)

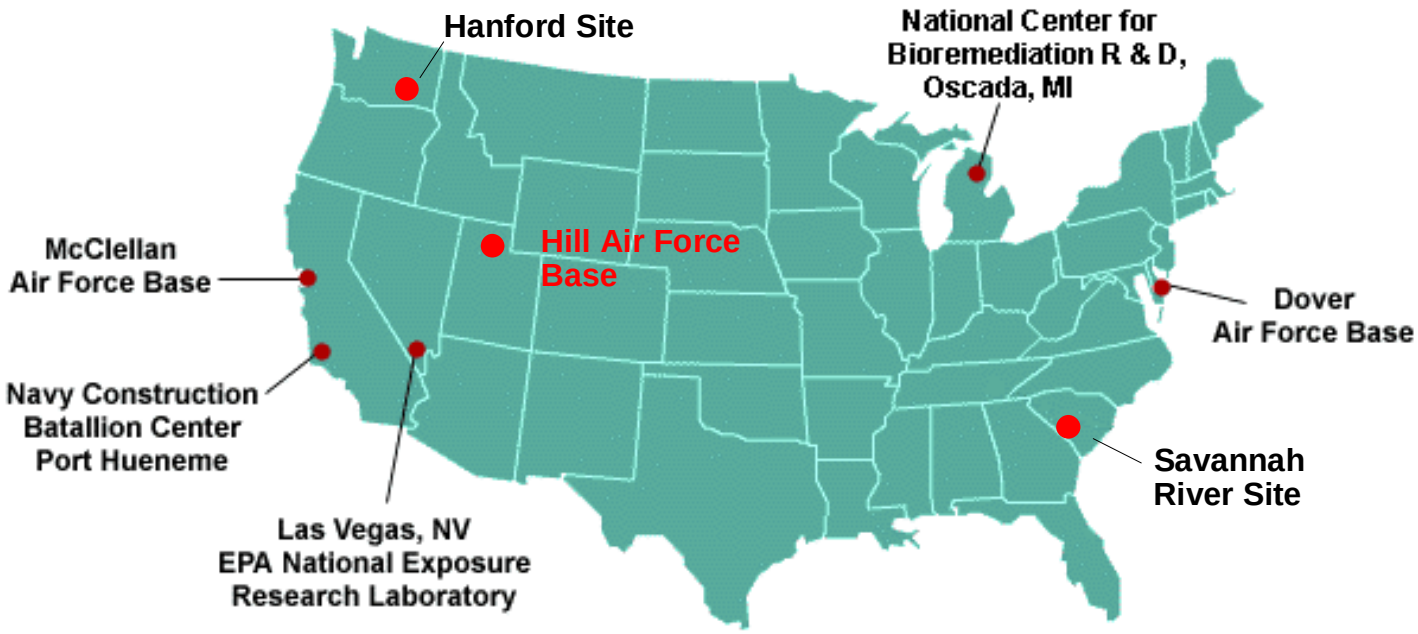
Controlled spill simulation



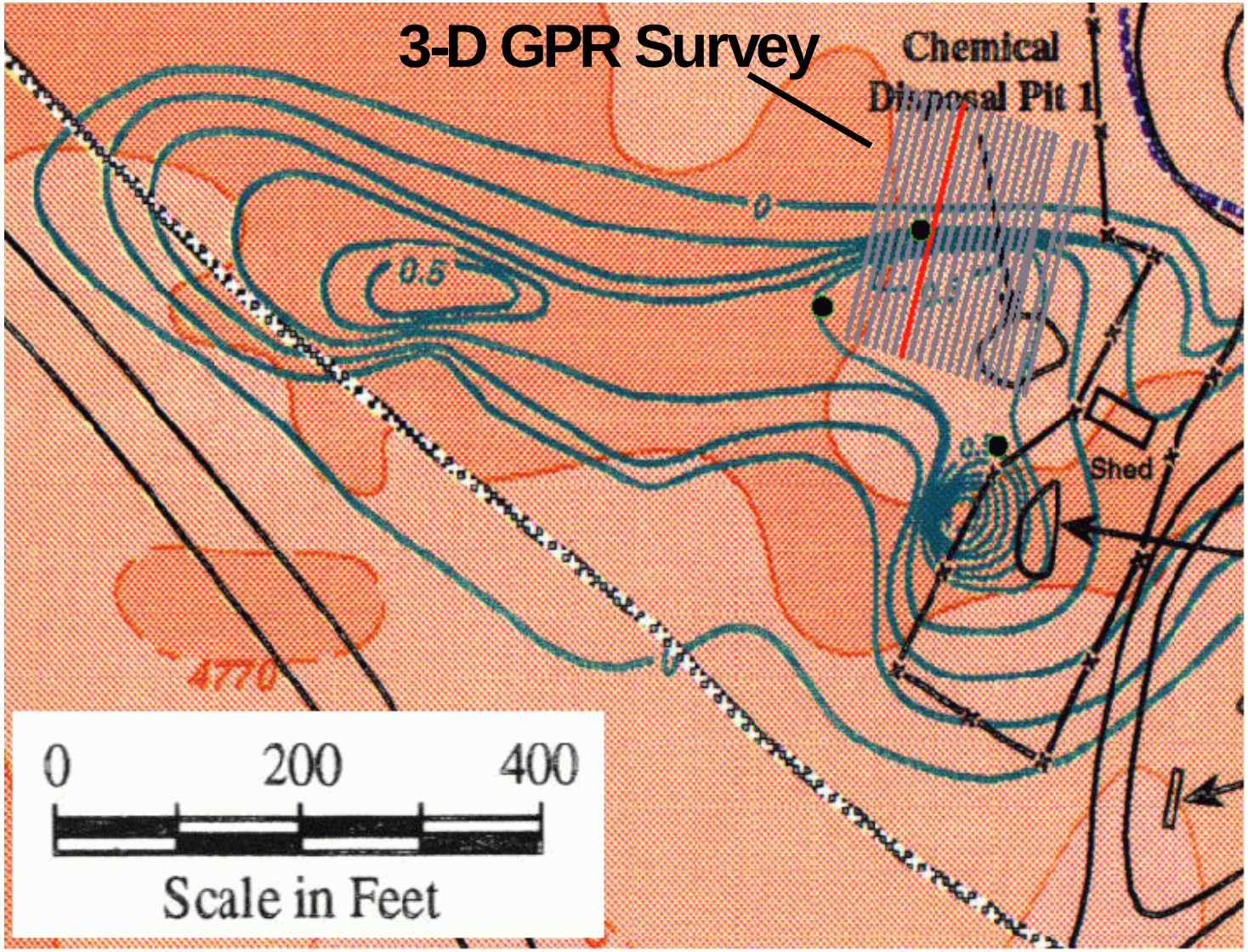


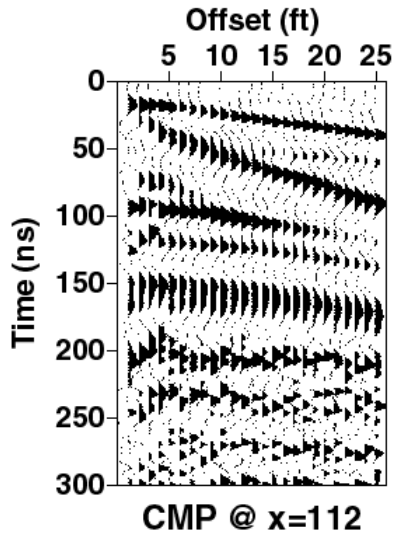

Velocity (ft/ns) at t=0
depth (m)
x (m)
0
0.5
1
1.5
2
2.5
3
3.5
400
350
300
250
200
150
Velocity (ft/ns) at t=5 hr
depth (m)
x (m)

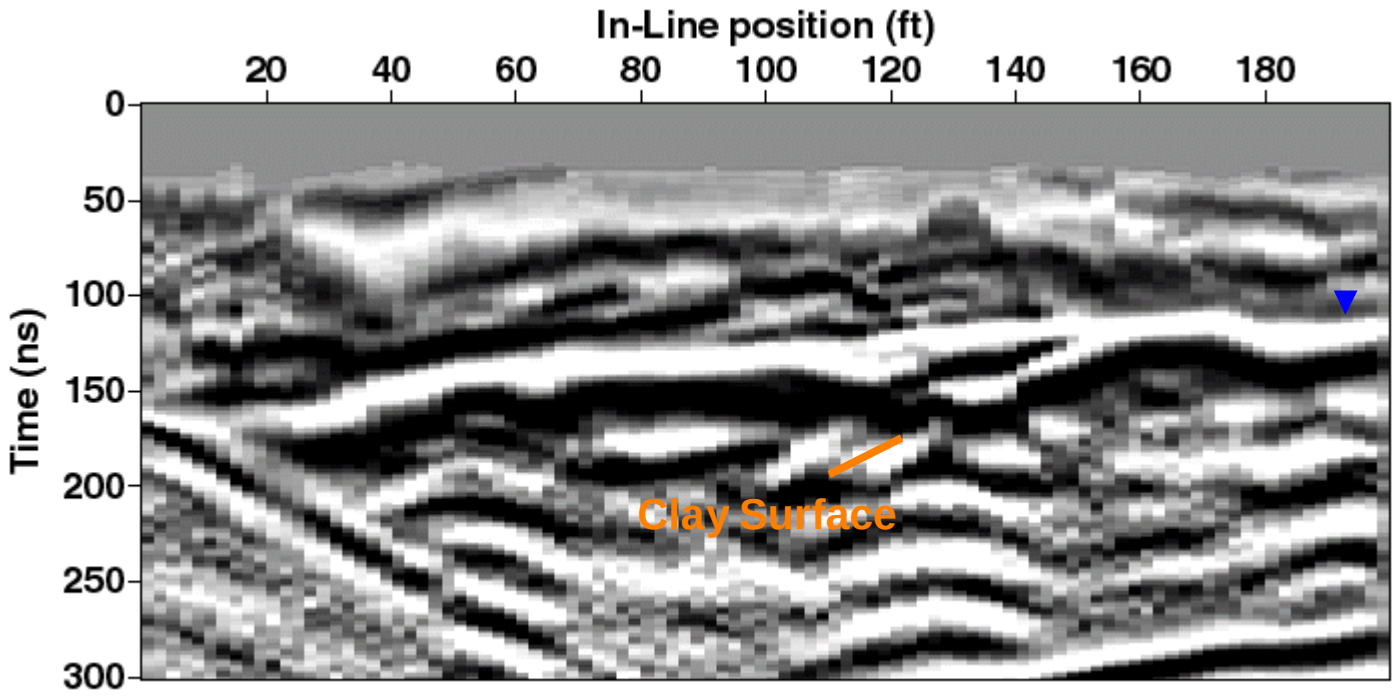
Field Locations



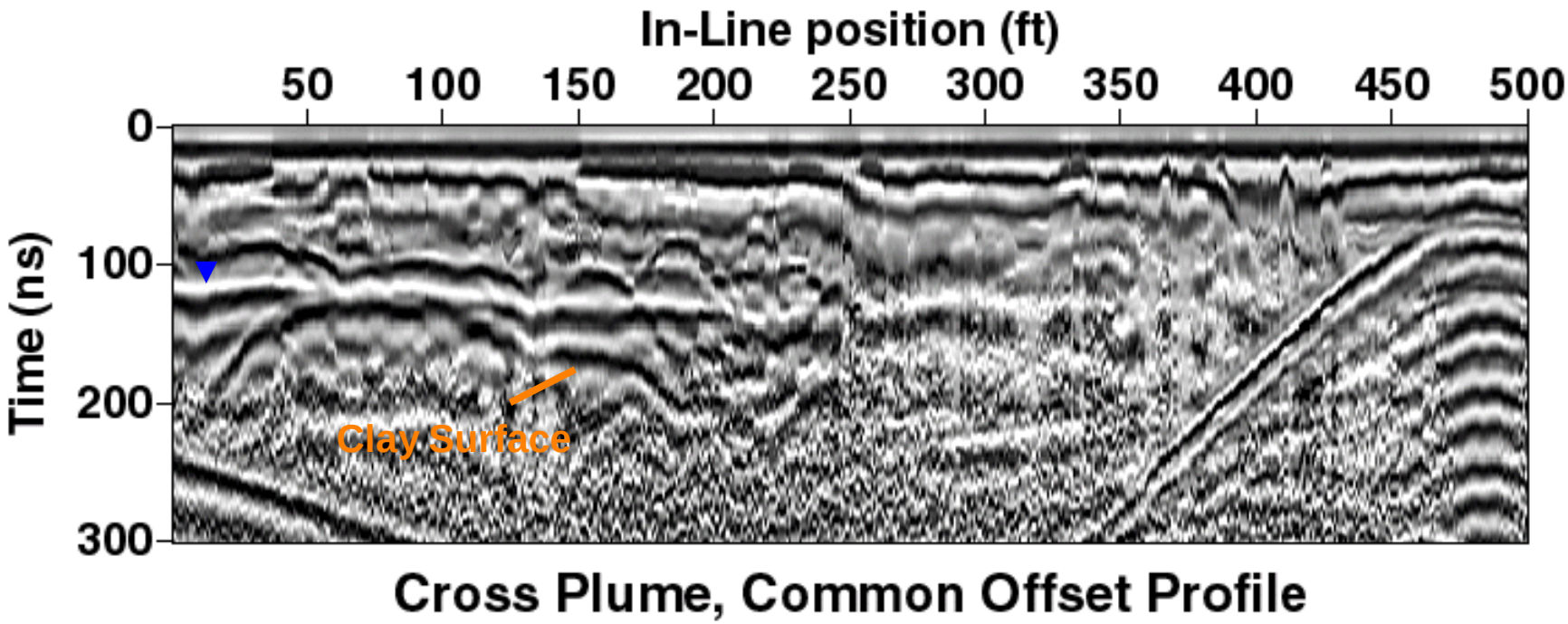
Hill AFB OU-1 LNAPL Plume





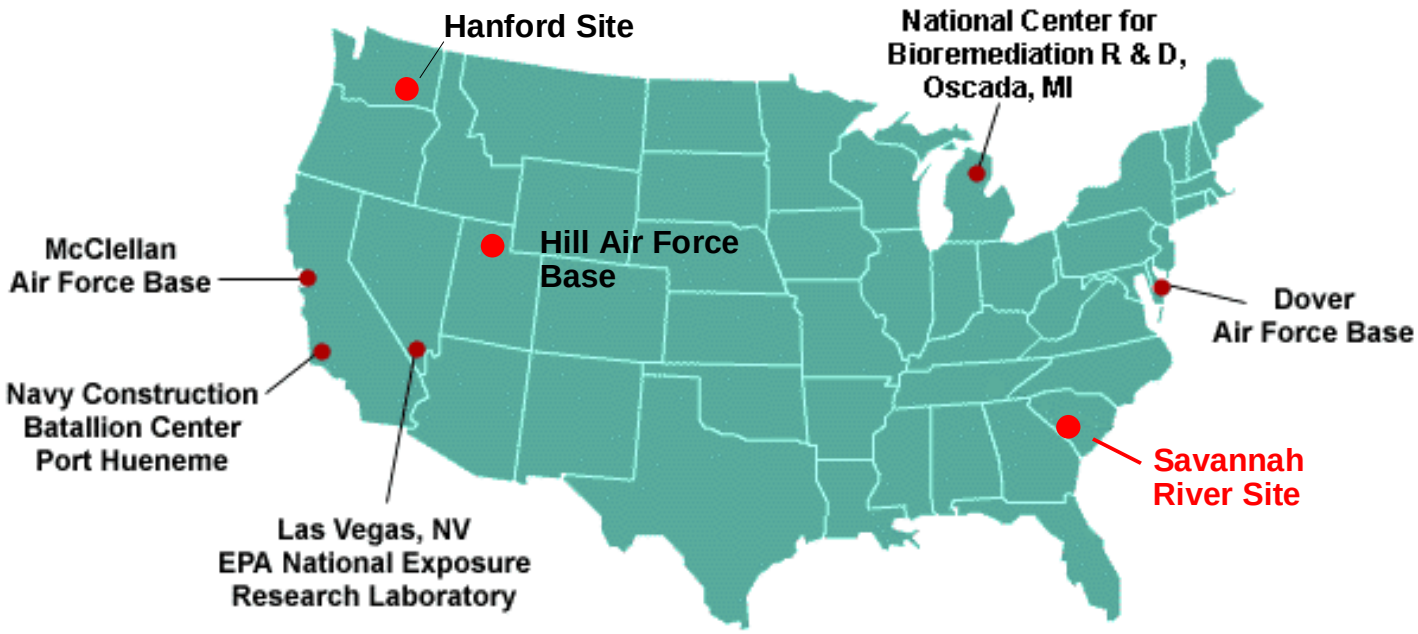


Line 14 Brute Stack

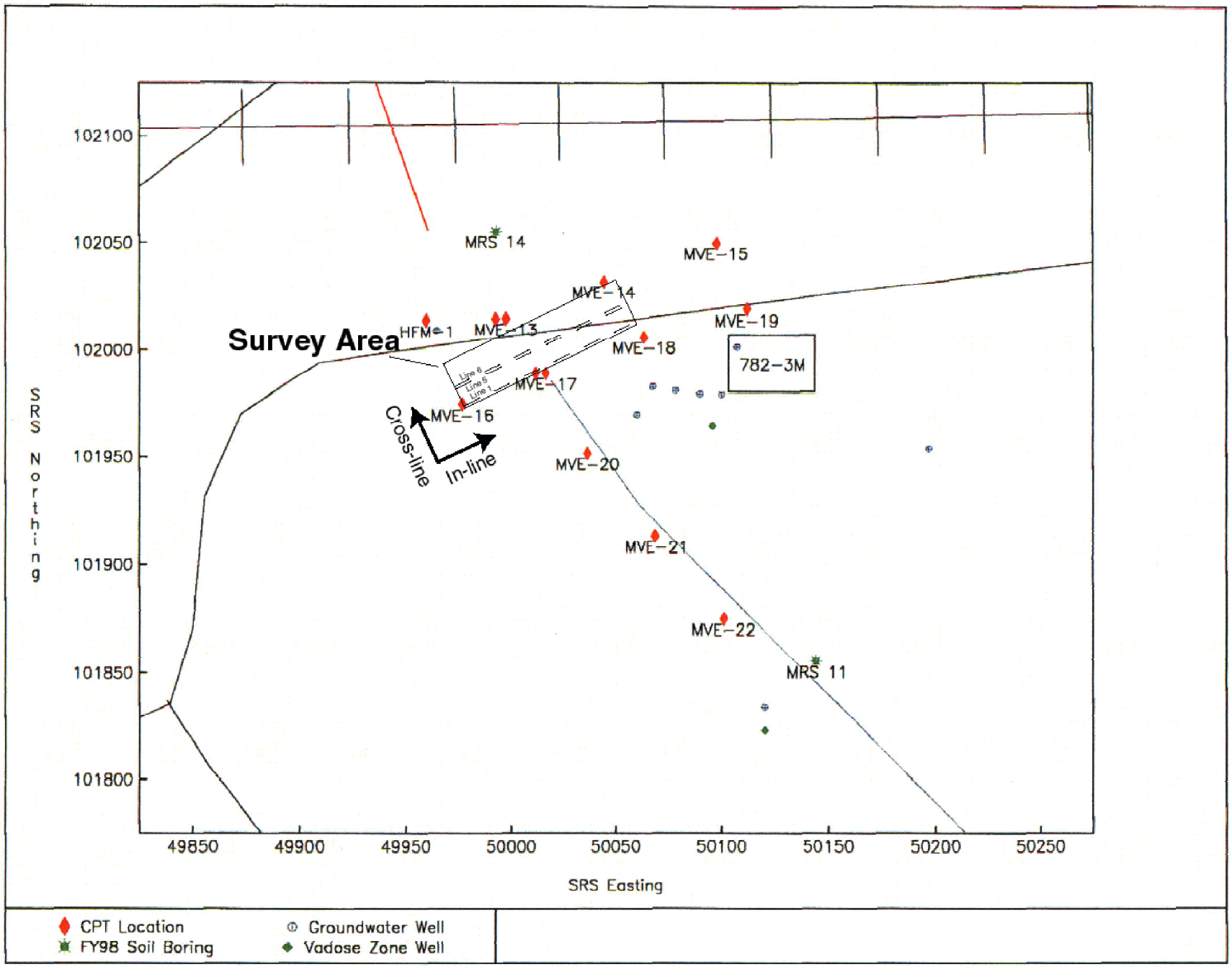


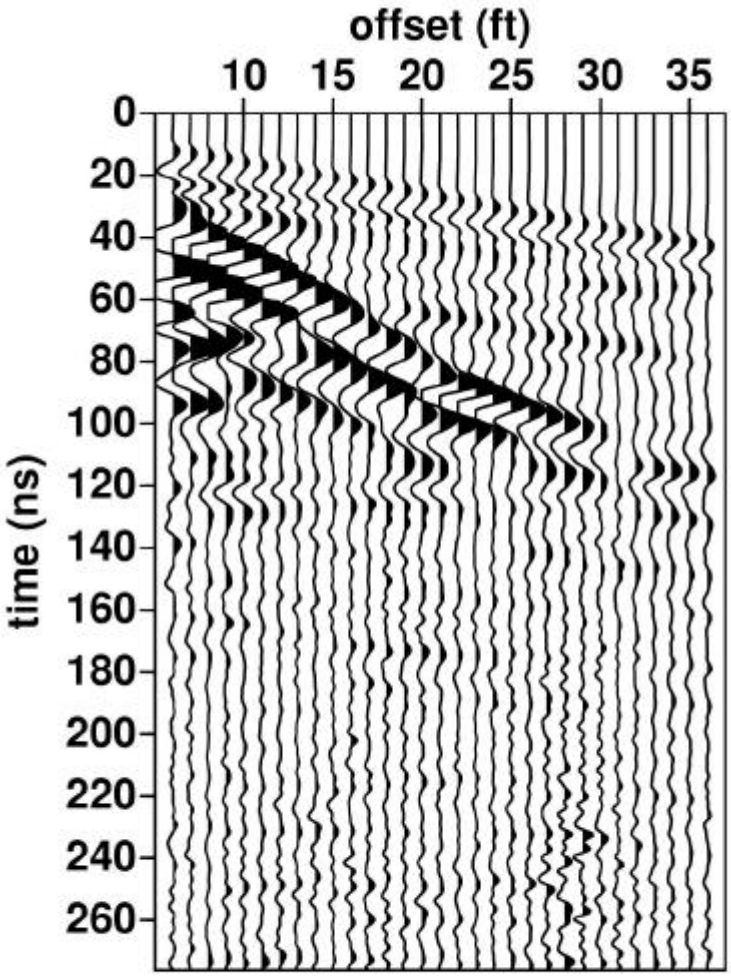
Cross Plume, Common Offset Profile

Field Locations

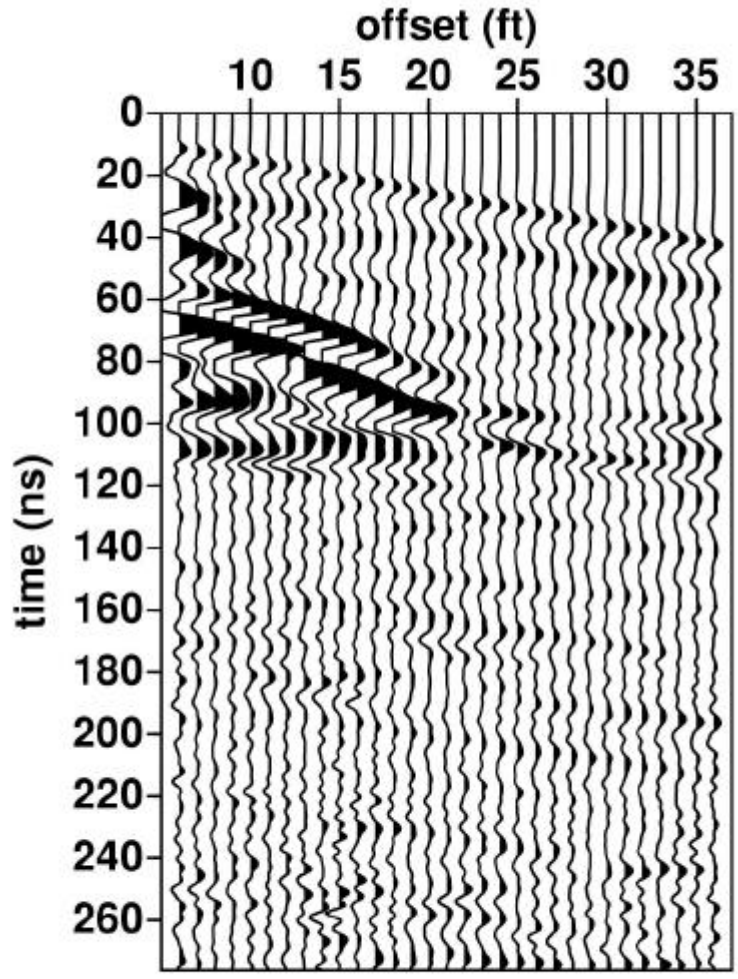


313-M
320-M
A14 Outfall

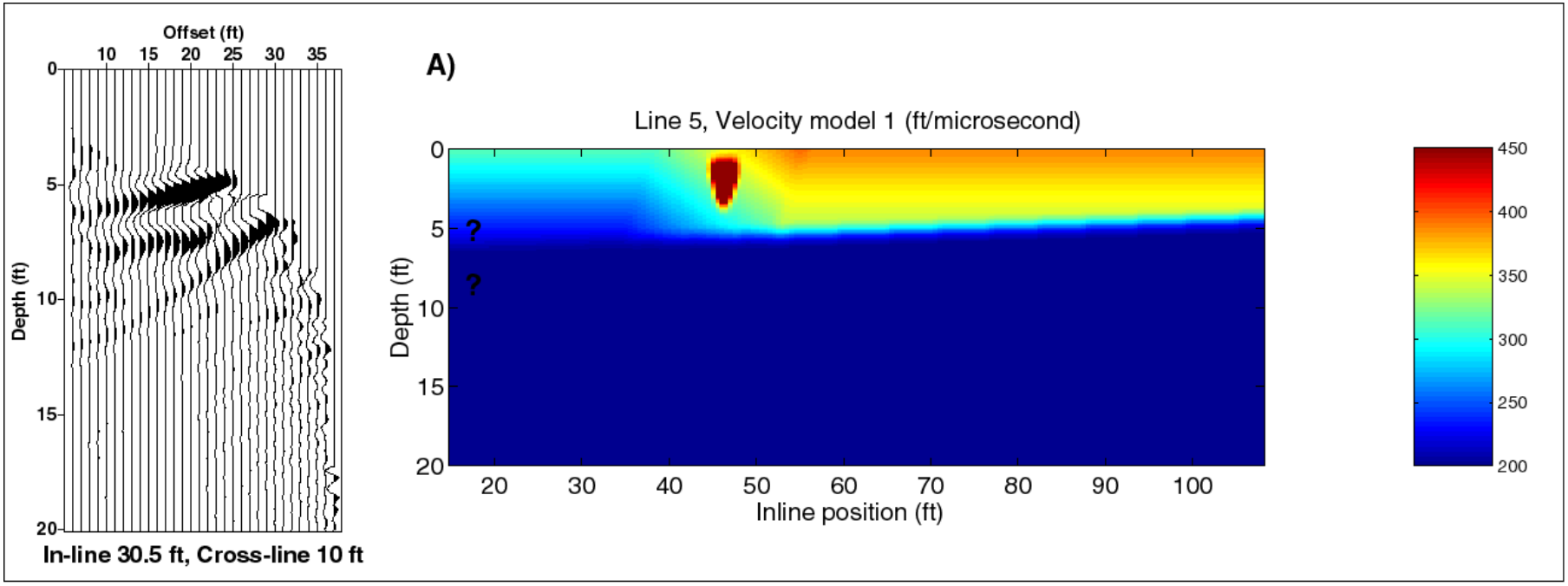

Survey Area
MRS 14
MVE-15
MVE-14
HFM-1
MVE-13
MVE-19
MVE-18
782-3M
MVE-17
MVE-16
Cross-line
In-line
MVE-20
MVE-21
MVE-22
MRS 11
102100
102050
102000
101950
101900
101850
101800
SRS Northing
49850
49900
49950
50000
50050
50100
50150
50200
50250
SRS Easting
CPT Location
FY98 Soil Boring
Groundwater Well
Vadose Zone Well

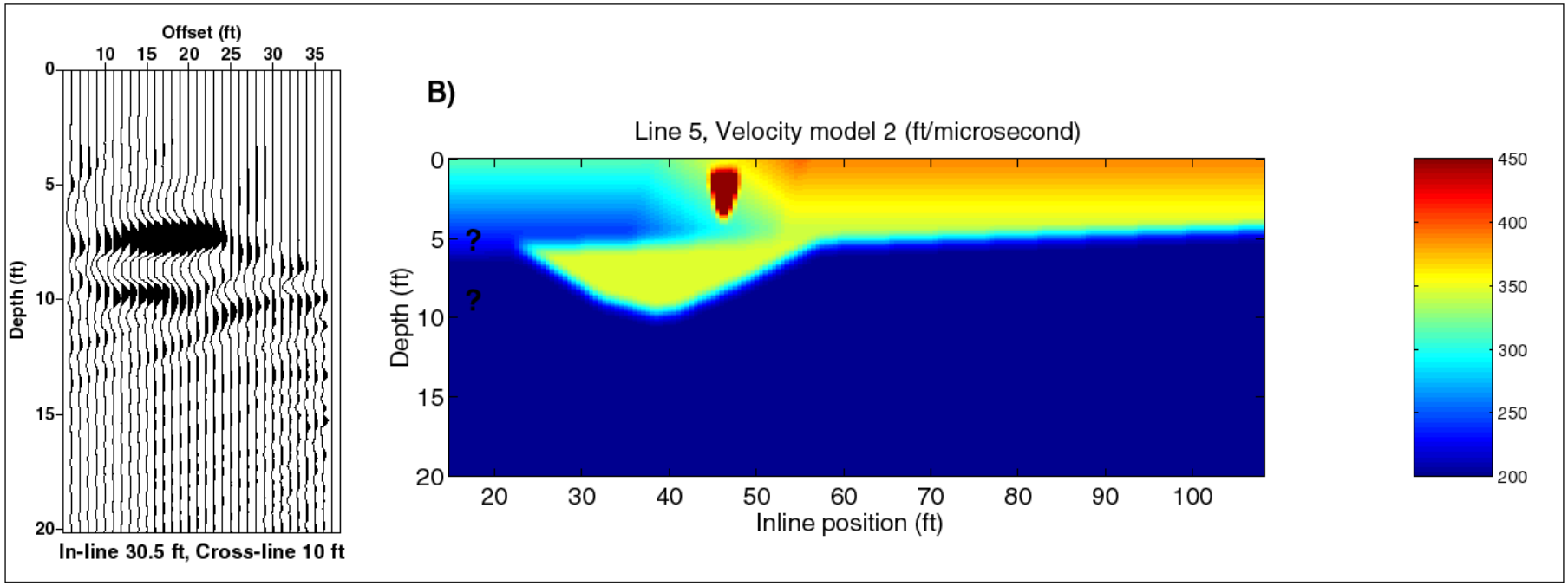


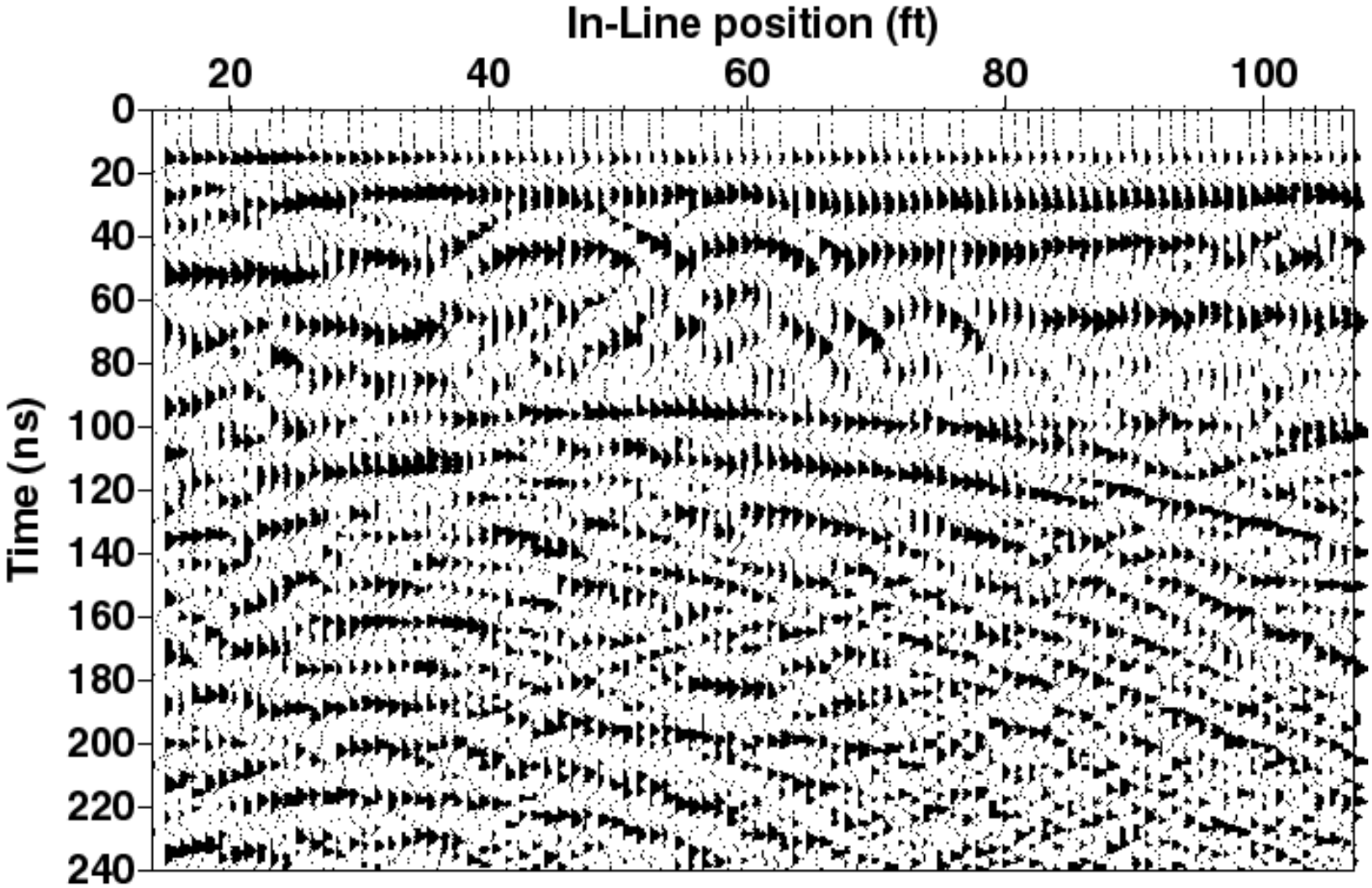
shot 7



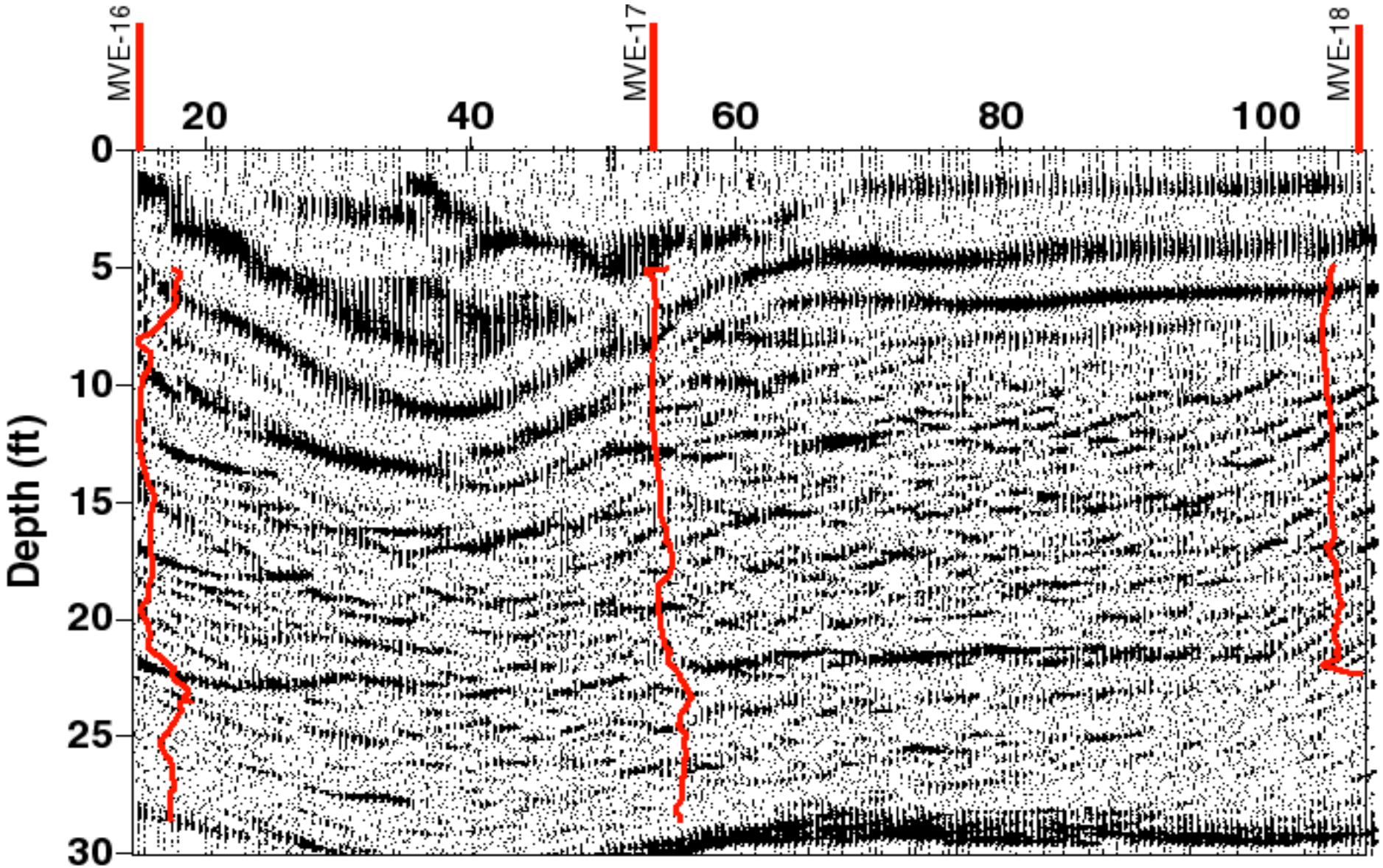
shot 14


Offset (ft)
10 15 20 25 30 35
Depth (ft)
0 5 10 15 20
In-line 30.5 ft, Cross-line 10 ft
A)
Line 5, Velocity model 1 (ft/microsecond)
Depth (ft)
0 5 10 15 20
?
?
20 30 40 50 60 70 80 90 100
Inline position (ft)
450 400 350 300 250 200

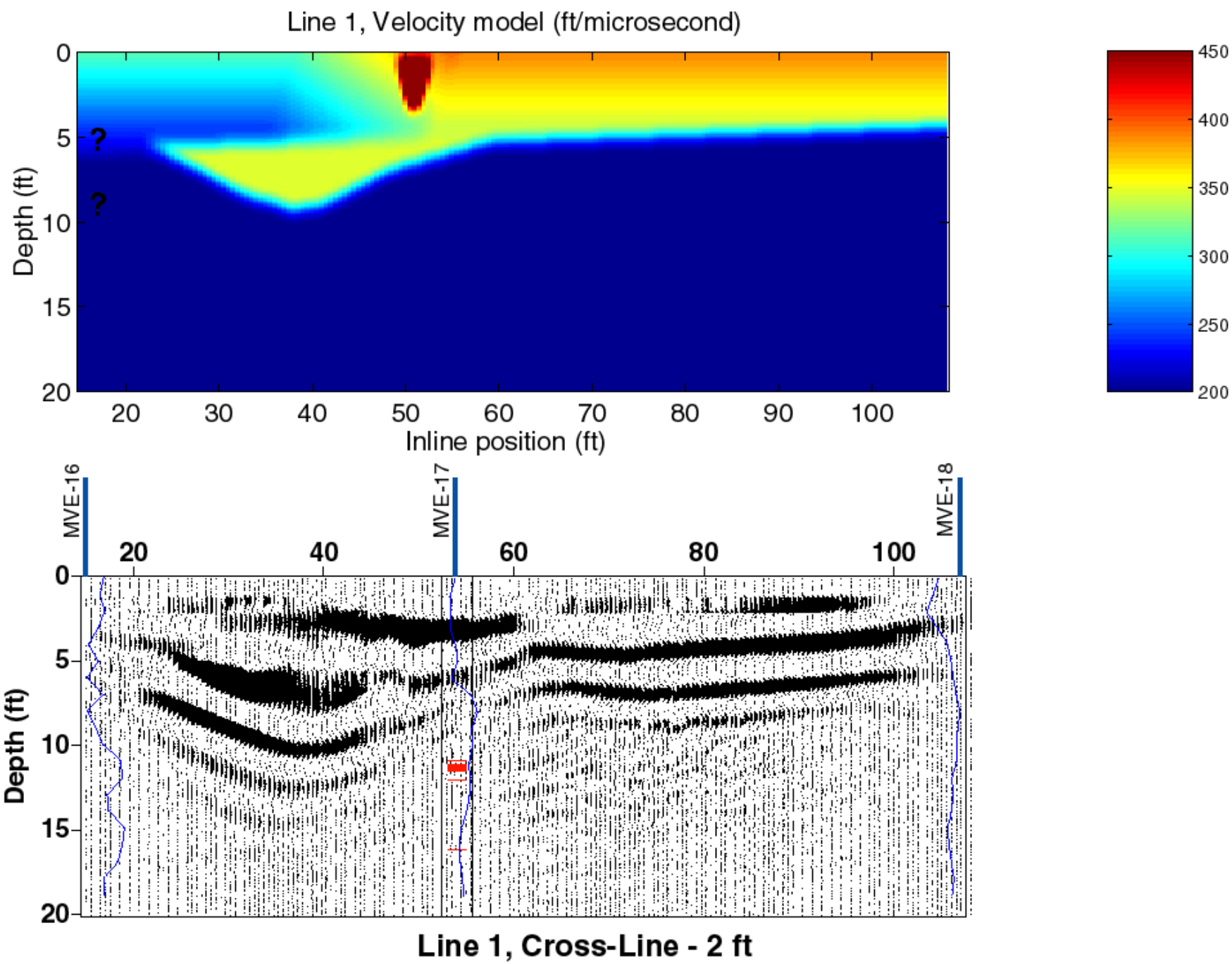

Offset (ft)
10 15 20 25 30 35
Depth (ft)
0 5 10 15 20
In-line 30.5 ft, Cross-line 10 ft
B)
Line 5, Velocity model 2 (ft/microsecond)
Depth (ft)
0 5 10 15 20
?
?
20 30 40 50 60 70 80 90 100
Inline position (ft)
450 400 350 300 250 200



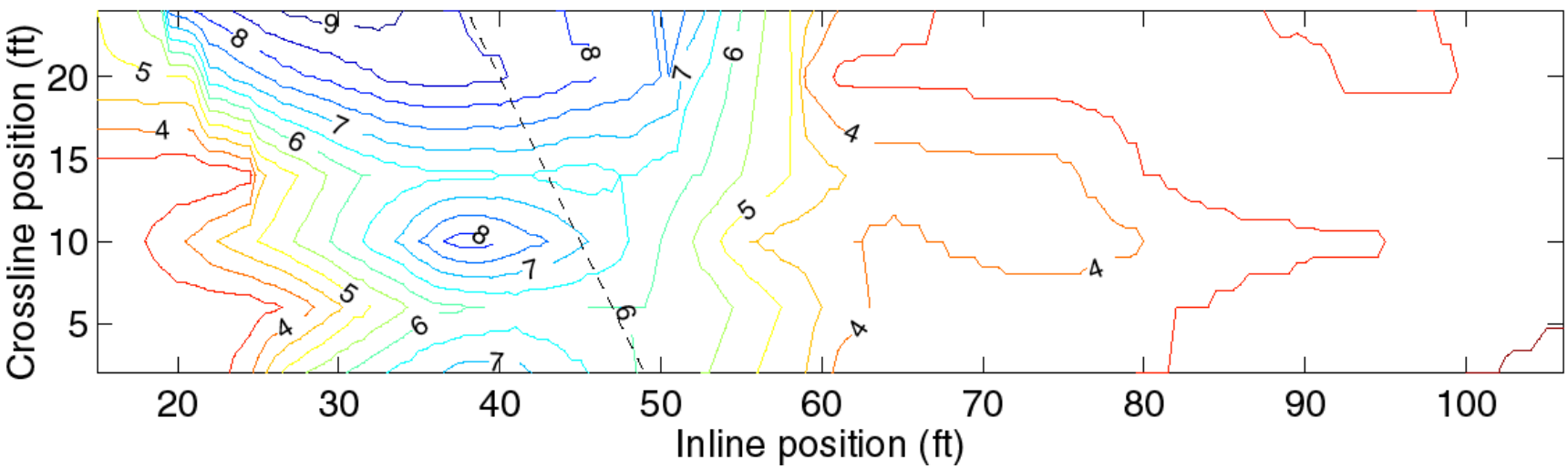
Line 6, Typical constant-offset GPR image

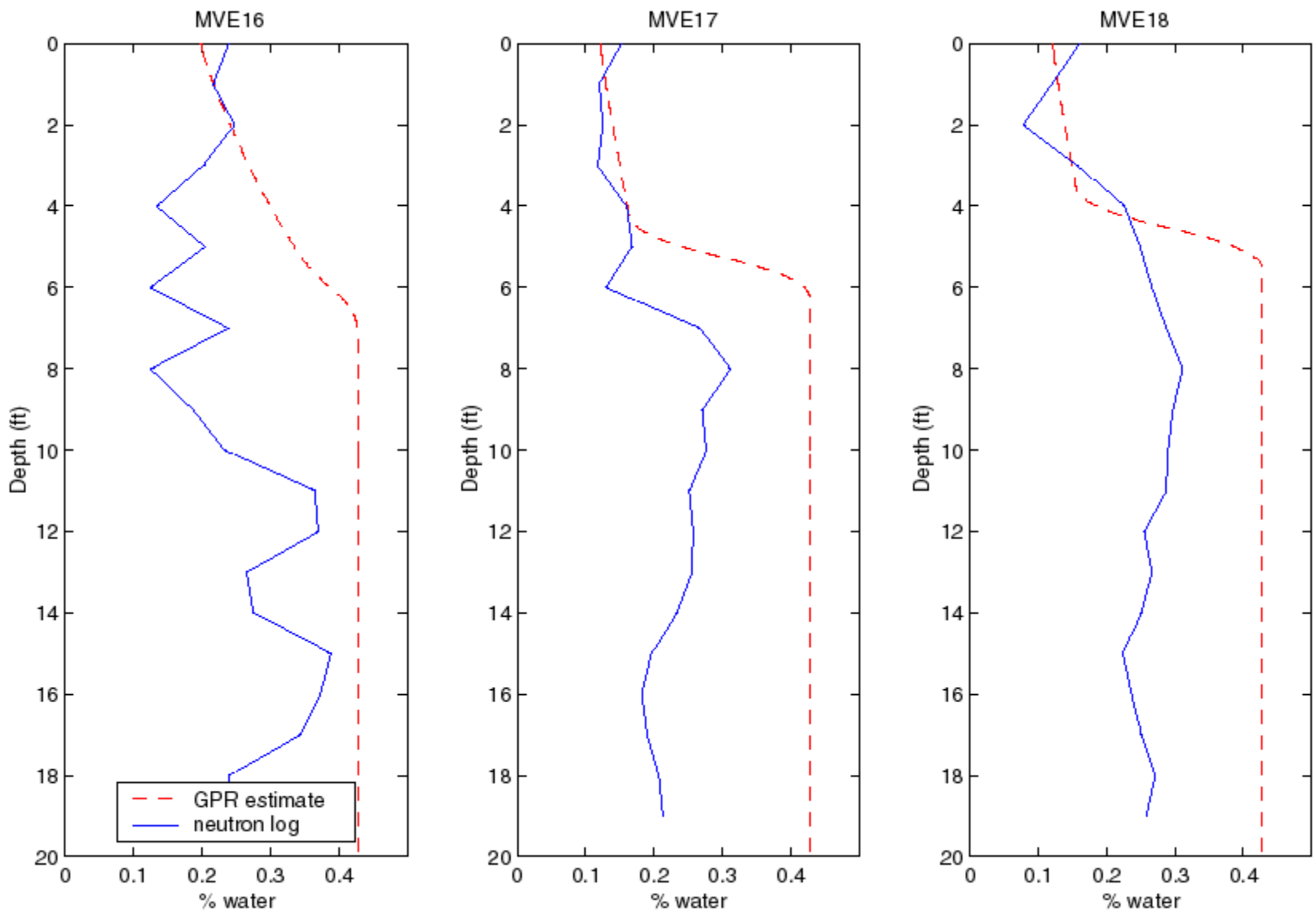


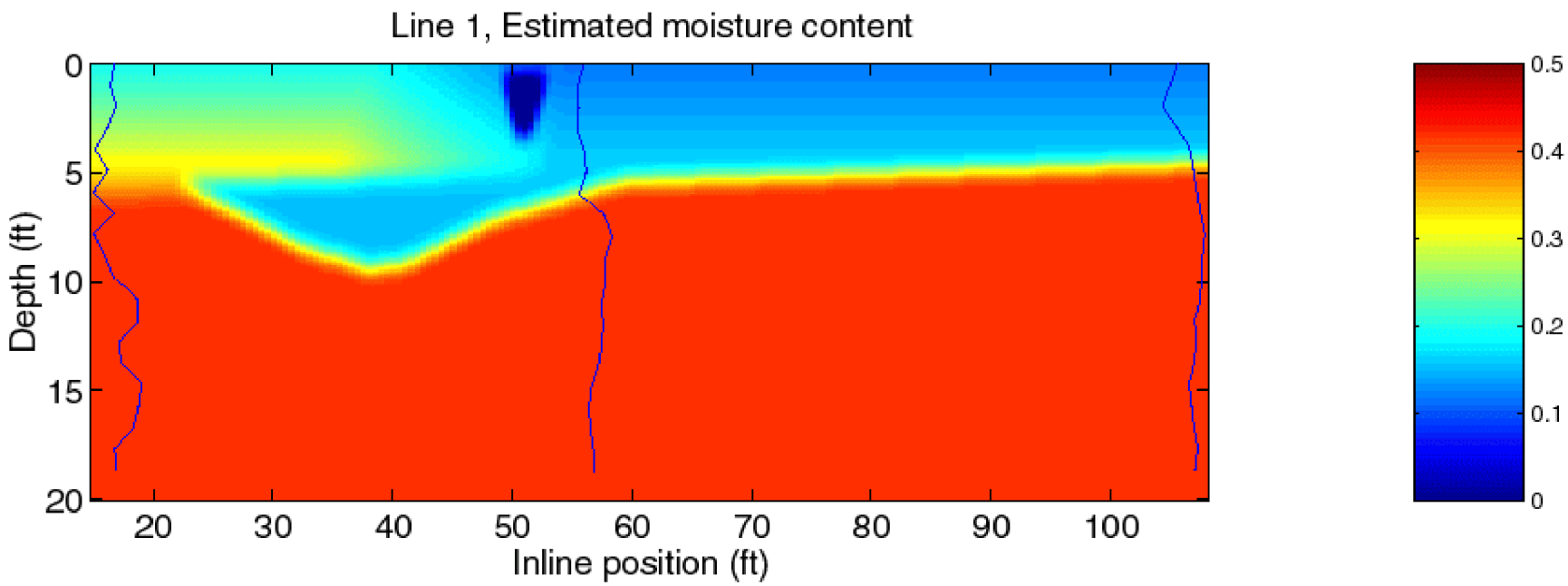
Line 5, Pre-stack depth migration w/agc

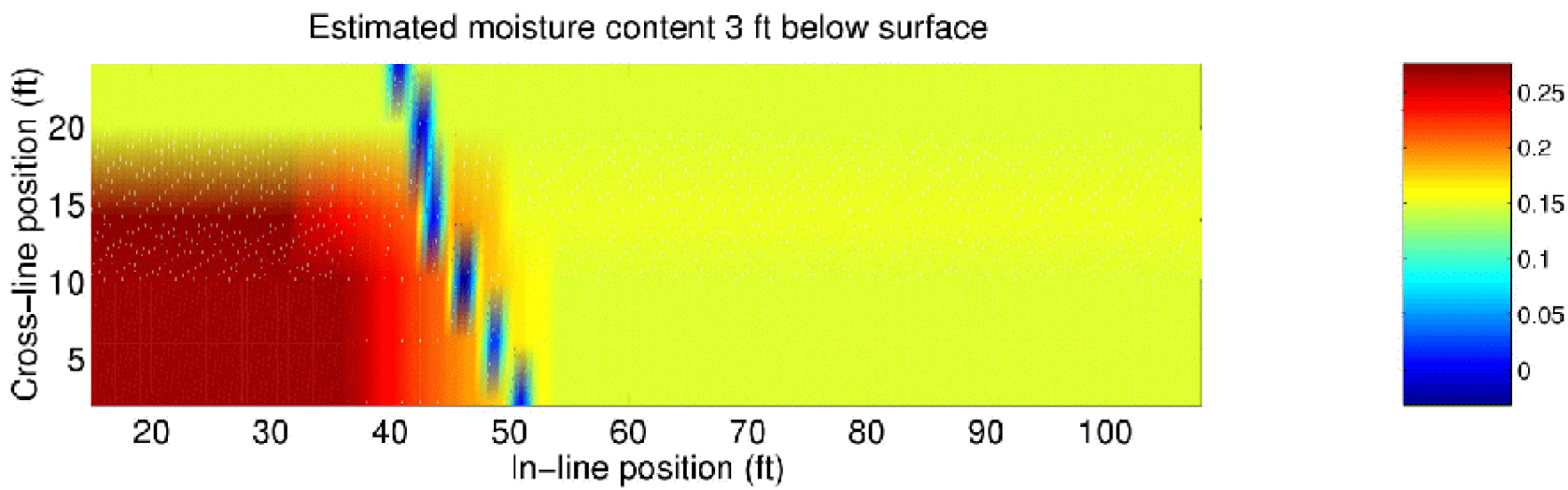

Line 1, Velocity model (ft/microsecond)
Depth (ft)
Inline position (ft)
0
5
10
15
20
20
30
40
50
60
70
80
90
100
?
?
450
400
350
300
250
200
MVE-16
MVE-17
MVE-18
20
40
60
80
100
Depth (ft)
Line 1, Cross-Line - 2 ft

Preliminary Interpretation of Clay Surface




MVE16
MVE17
MVE18
Depth (ft)
% water
GPR estimate
neutron log
0
2
4
6
8
10
12
14
16
18
20
0
0.1
0.2
0.3
0.4


Line 1, Estimated moisture content
Depth (ft)
0
5
10
15
20
20
30
40
50
60
70
80
90
100
Inline position (ft)
0.5
0.4
0.3
0.2
0.1
0


Estimated moisture content 3 ft below surface
Cross−line position (ft)
20
15
10
5
20
30
40
50
60
70
80
90
100
In−line position (ft)
0.25
0.2
0.15
0.1
0.05
0

Progress Summary

- Integrating 3-phase flow and geophysical models
  - Dover AFB simulations give promising results
- Hill AFB
  - Detailed imaging of channels
  - Possible detection of smear zone
- Savannah River
  - 3-D imaging of channel
  - Possible detection of DNAPL pool using migration velocity analysis

Project Schedule

- Dover AFB
  - < Winter 2000/2001
- Radar Modeling Code
  - < Spring 2001
- Hanford Site
  - < Spring 2001
- Former Ft. Wurtsmith AFB, Ft. McClellan AFB
  - < Summer 2001