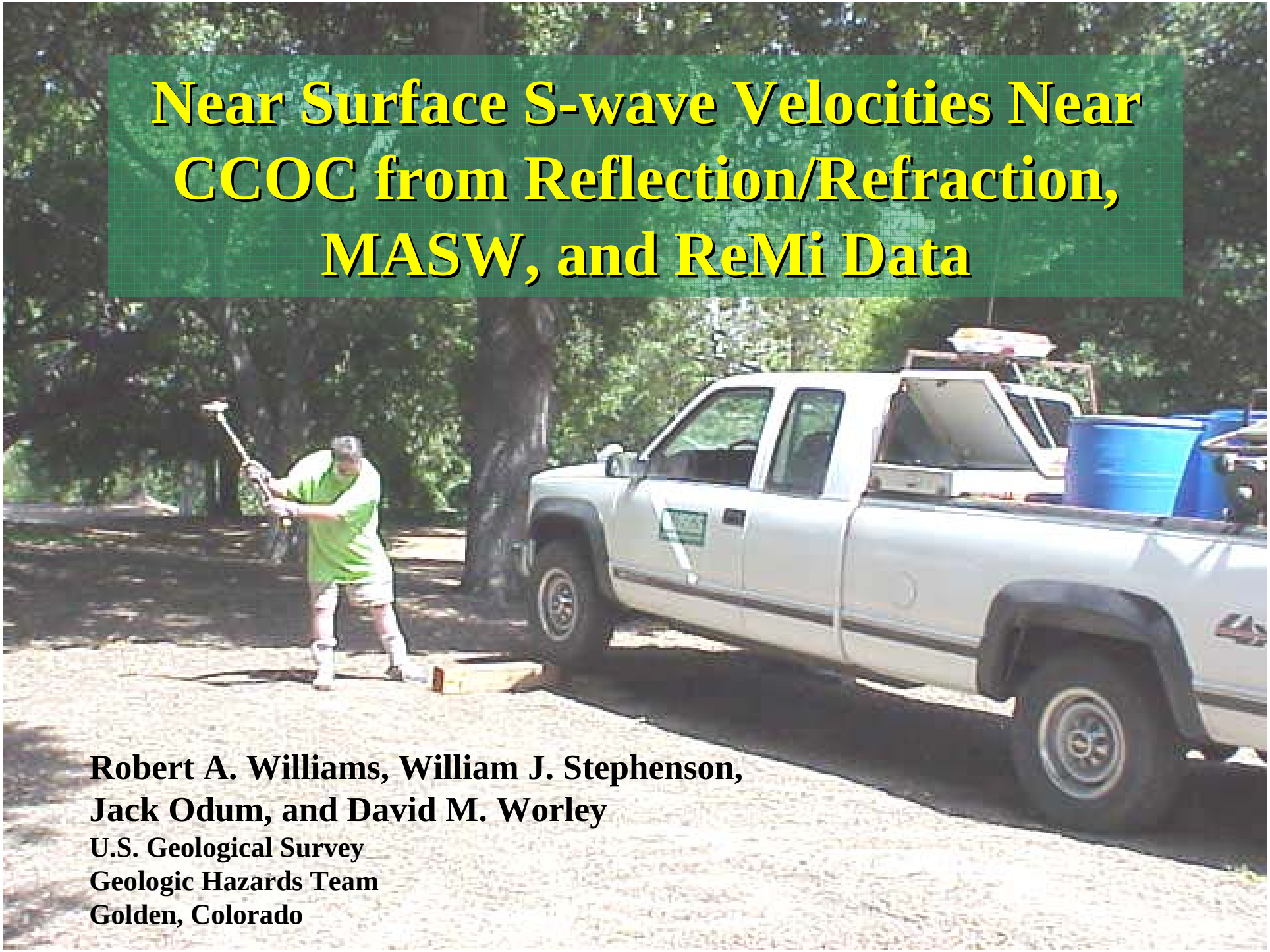
This slide presentation was presented at the May 3, 2004 Coyote Creek Shear velocity Comparison Workshop at the USGS, Menlo Park, CA.

This is an extract from Asten, M.W., and Boore, D.M., eds., Blind comparisons of shear-wave velocities at closely spaced sites in San Jose, California: U.S. Geological Survey Open-File Report 2005-1169. [available on the World Wide Web at http://pubs.usgs.gov/of/2005/1169/].

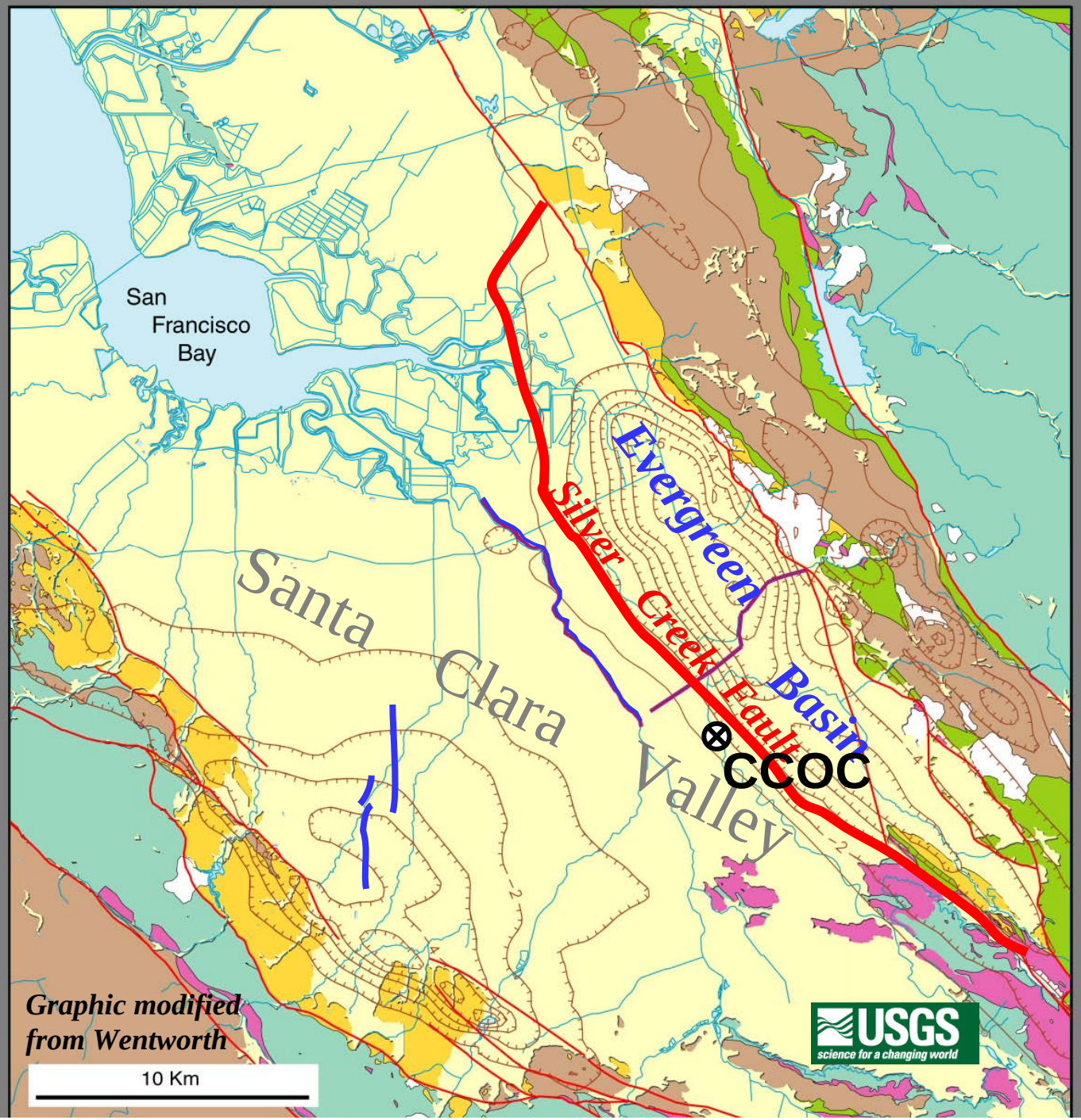
2005

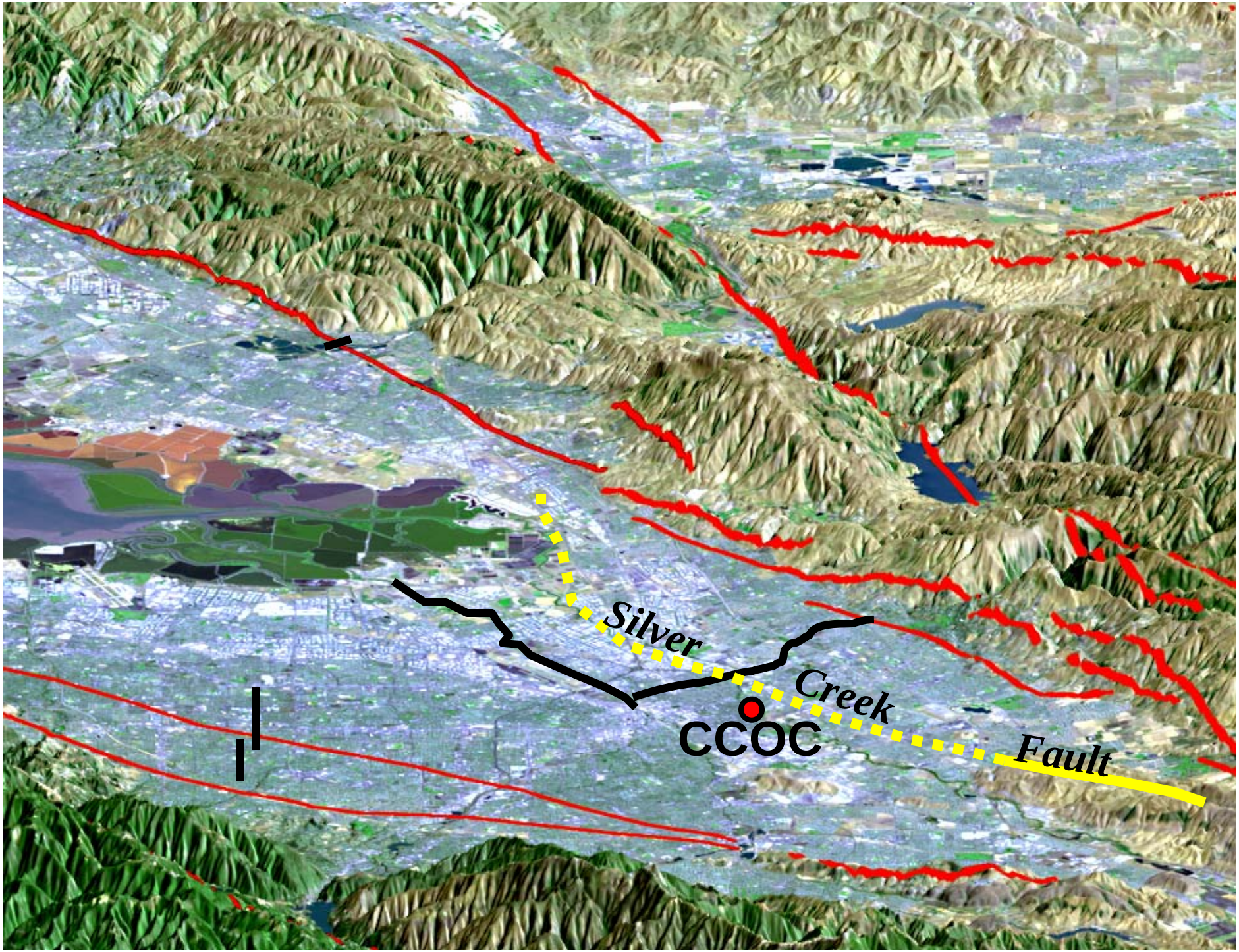
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

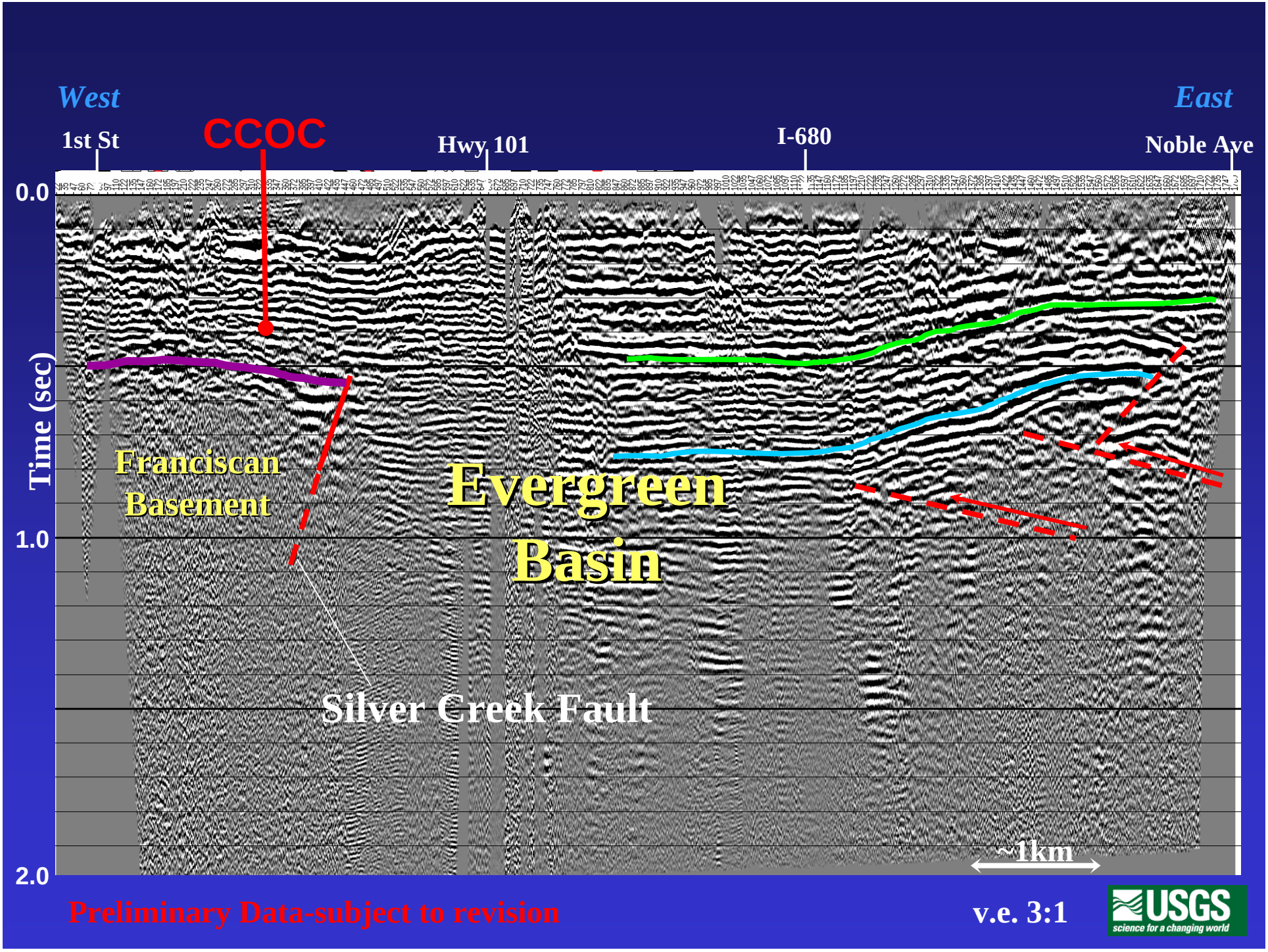
Near Surface S-wave Velocities Near CCOC from Reflection/Refraction, MASW, and ReMi Data



Robert A. Williams, William J. Stephenson, Jack Odum, and David M. Worley
U.S. Geological Survey
Geologic Hazards Team
Golden, Colorado


San
Francisco
Bay
Santa
Clara
Valley
Evergreen Basin
Silver Creek Fault
CCOC
Graphic modified
from Wentworth
10 Km
USGS
science for a changing world


Silver
Creek
Fault
CCOC

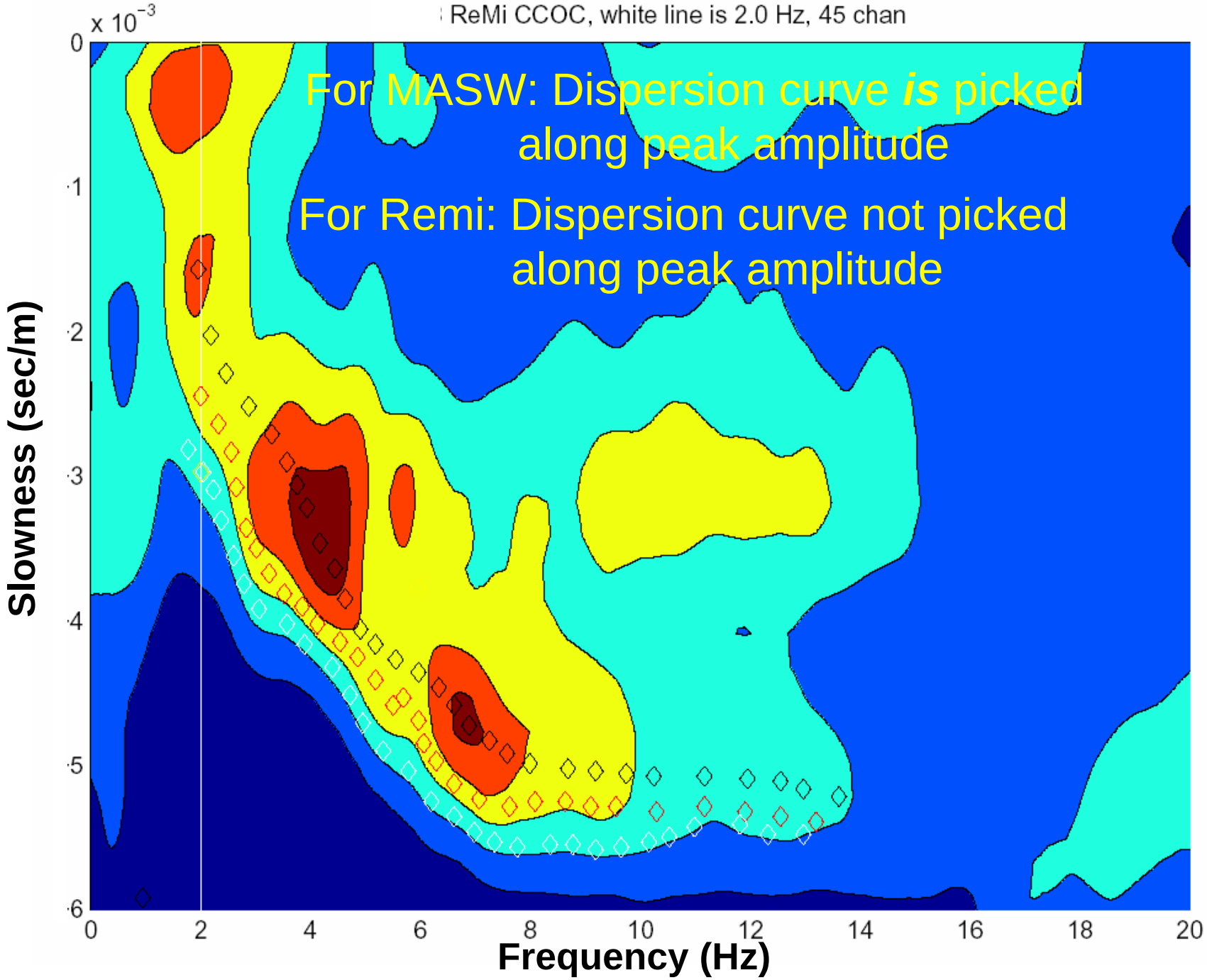

West
East
CCOC
1st St
Hwy 101
I-680
Noble Ave
0.0
1.0
2.0
Time (sec)
Franciscan
Basement
Evergreen
Basin
Silver Creek Fault
~1km
Preliminary Data-subject to revision
v.e. 3:1
USGS
science for a changing world

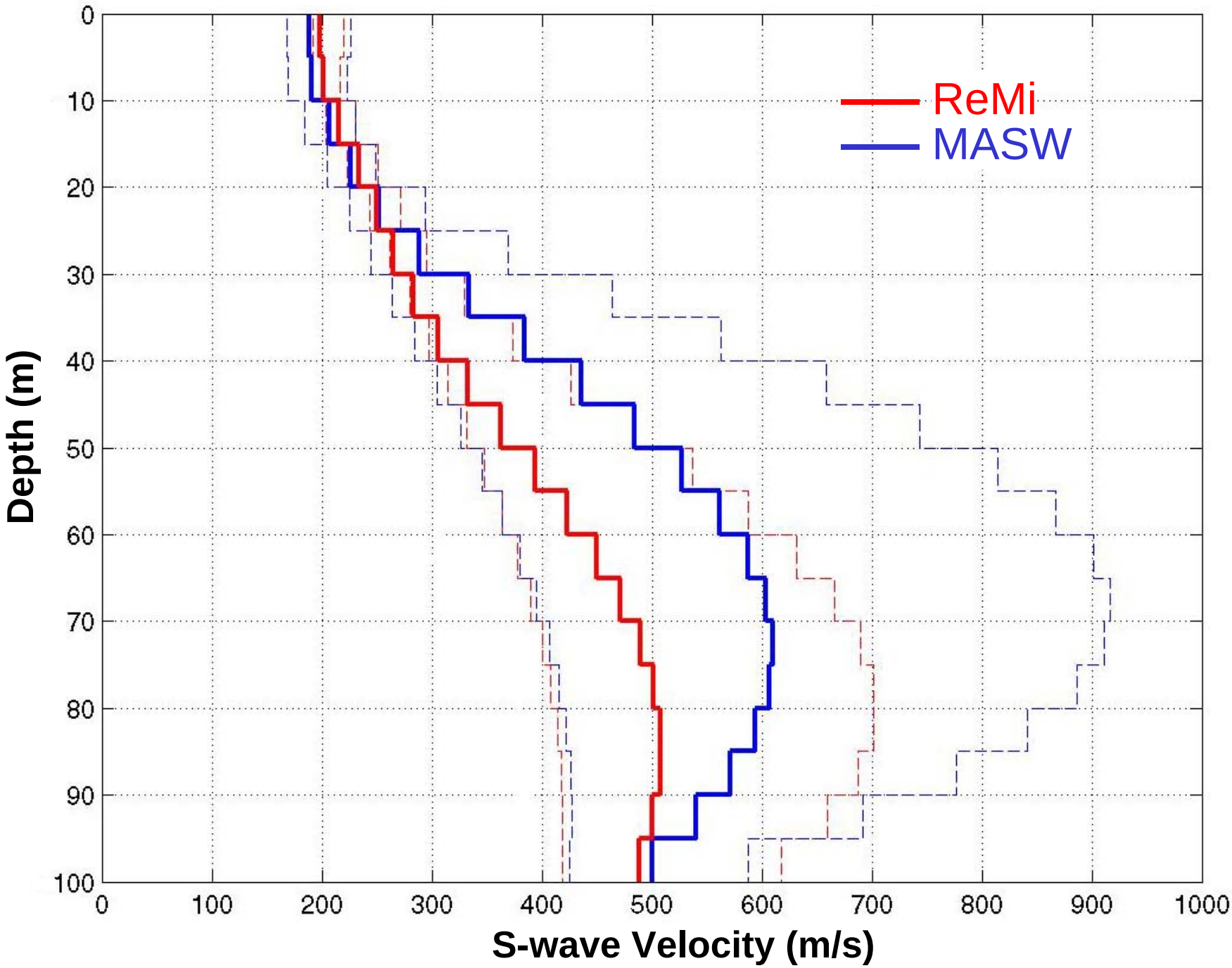
Aerial photo modified from http://nationalmap.usgs.gov/


CCOC
Seismic line for:
Reflection/Refraction
MASW
ReMi
200 m
USGS
Aerial photo modified from http://nationalmap.usgs.gov/

100 kg Elastically-Accelerated Weight Drop for MASW and P-wave reflection/refraction surveys


ReMi / MASW
Linear Array
45 channels/record
5-m sensor spacing
4.5-Hz vert. sensor
ReMi:
2 ms sample interval
30-sec record length
MASW:
1 ms samp. int.
2-sec record length
4. 10. 2003

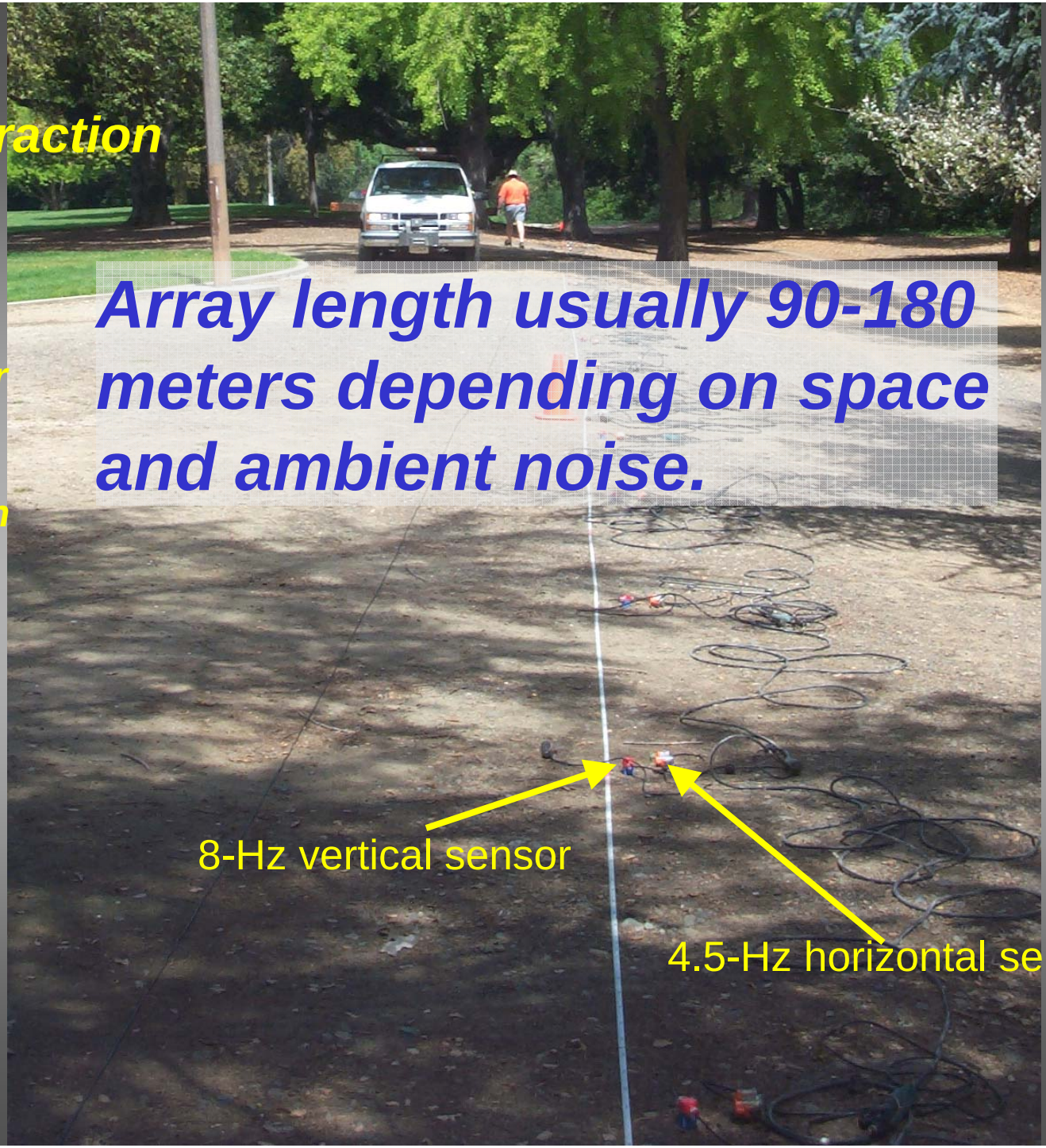

ReMi CCOC, white line is 2.0 Hz, 45 chan
x 10^-3
0
-1
-2
-3
-4
-5
-6
Slowness (sec/m)
0
2
4
6
8
10
12
14
16
18
20
Frequency (Hz)
For MASW: Dispersion curve *is* picked along peak amplitude
For Remi: Dispersion curve not picked along peak amplitude

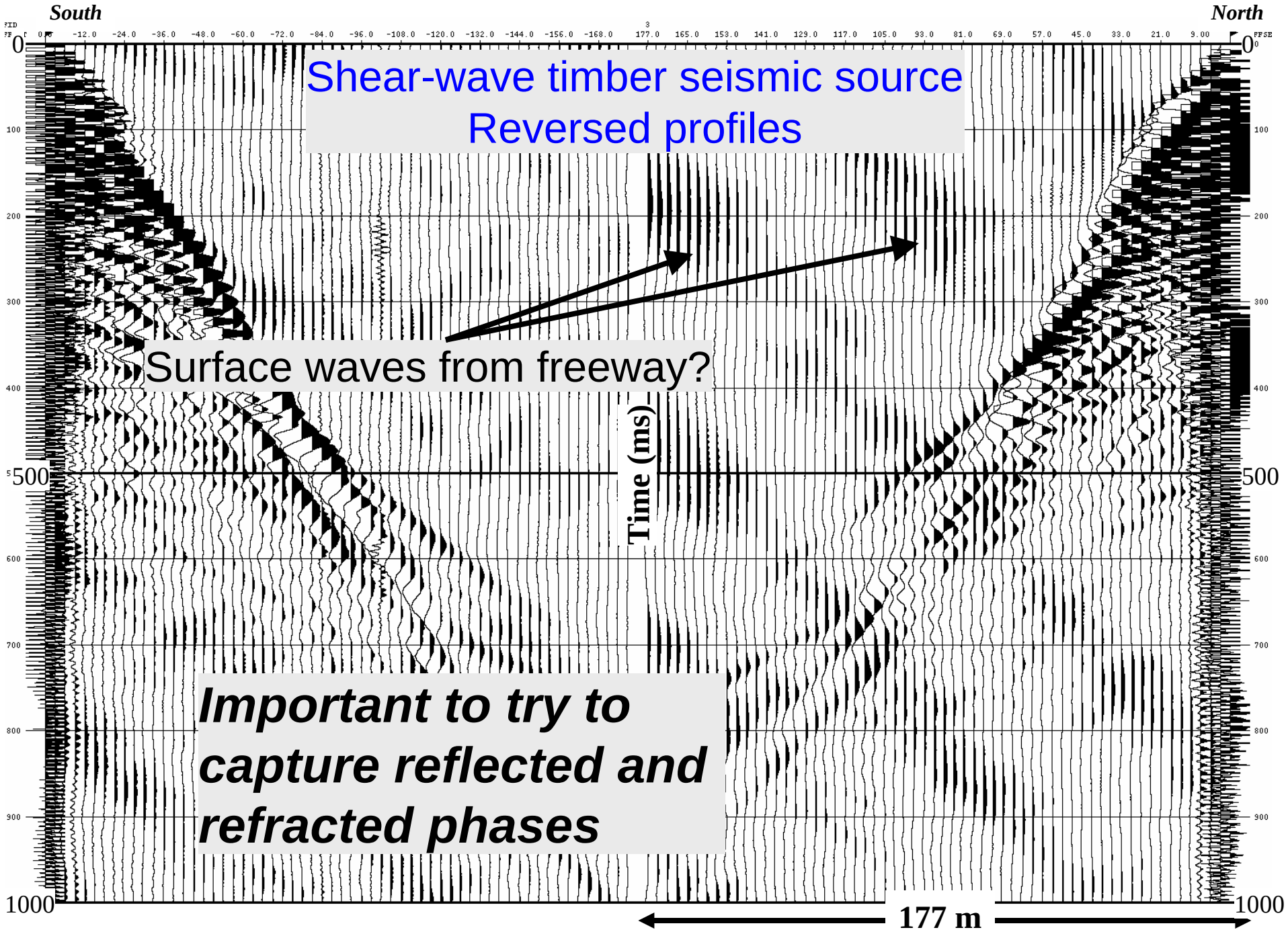

ReMi
MASW
Depth (m)
S-wave Velocity (m/s)
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700
800
900
1000


4.5-kg sledgehammer
Wood beam

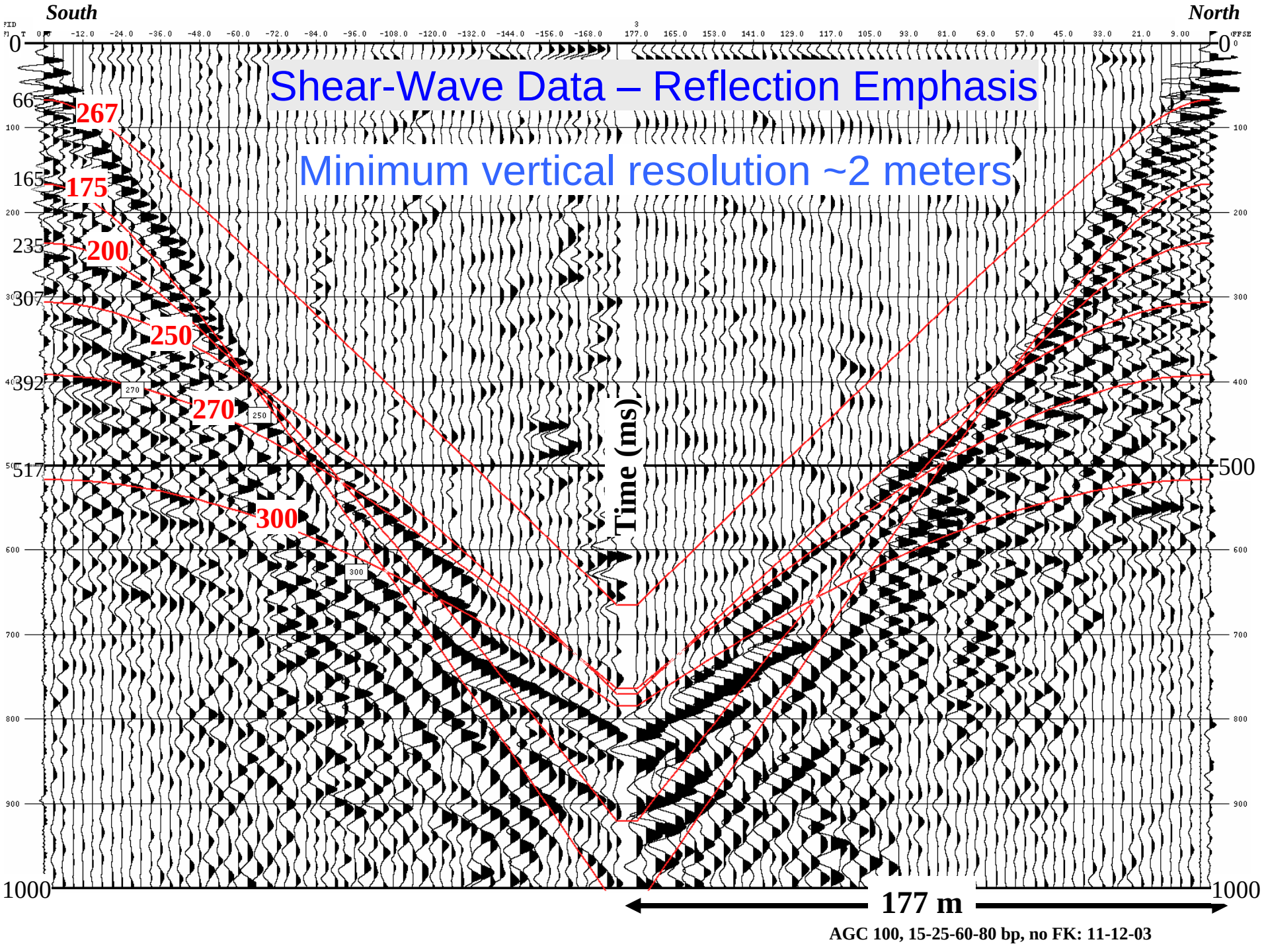
P- & S-wave Reflection/Refraction Data:

60 channels/record
3-m sensor spacing
8.0 Hz vertical sensor
4.5 Hz horizontal
1 ms sample interval
2.0 sec. record length




South
North
Shear-wave timber seismic source
Reversed profiles
Surface waves from freeway?
Time (ms)
Important to try to capture reflected and refracted phases
177 m
NO filter, AGC or FK, true relative amps: 11-5-03

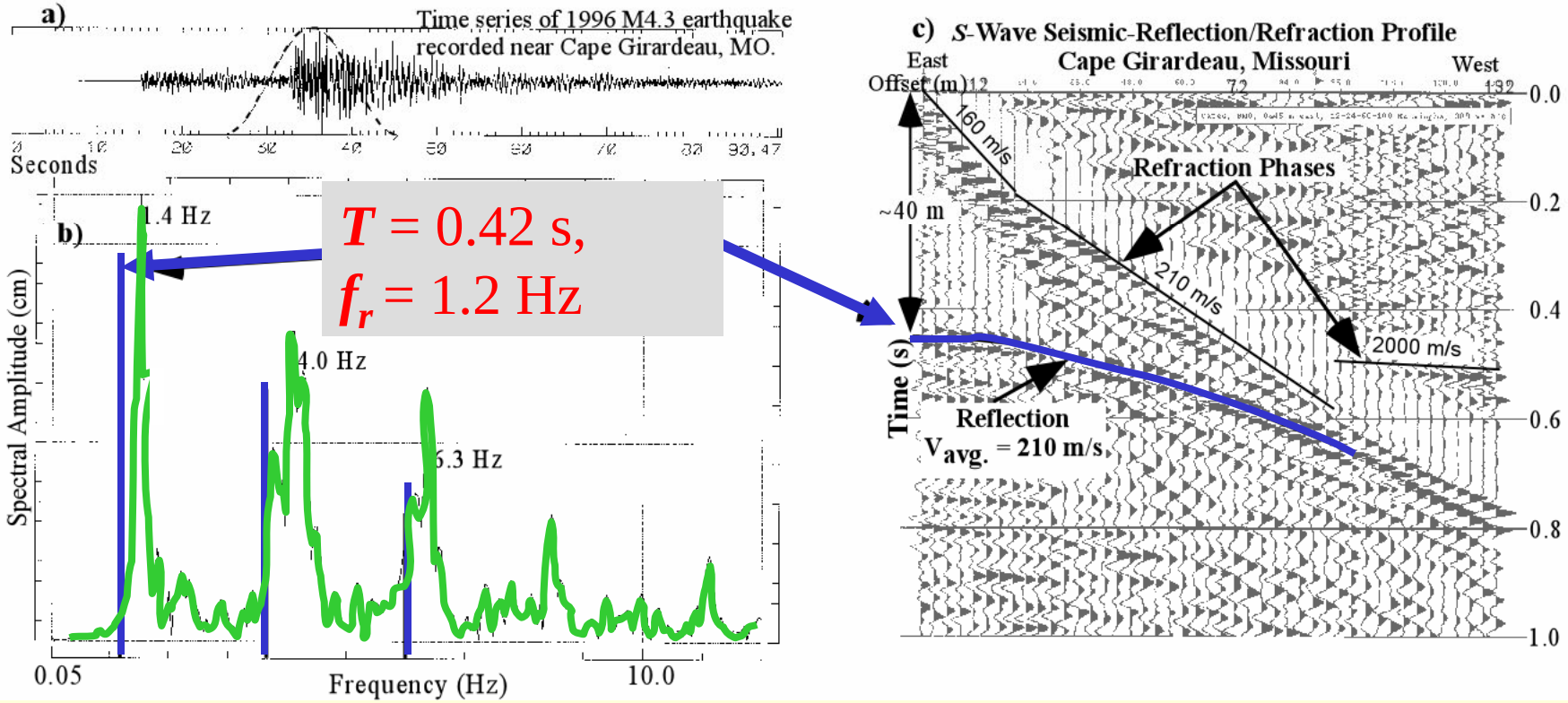

South
North
Shear-Wave Data – Reflection Emphasis
Time (ms)
0
100
200
300
400
500
600
700
800
900
1000
177 m
AGC 350, 10-20-60-100 bp, FK -300-300 m/s: 11-5-03


South
North
Shear-Wave Data – Reflection Emphasis
Minimum vertical resolution ~2 meters
267
175
200
250
270
300
Time (ms)
0
66
100
165
200
235
307
392
500
517
600
700
800
900
1000
177 m
AGC 100, 15-25-60-80 bp, no FK: 11-12-03

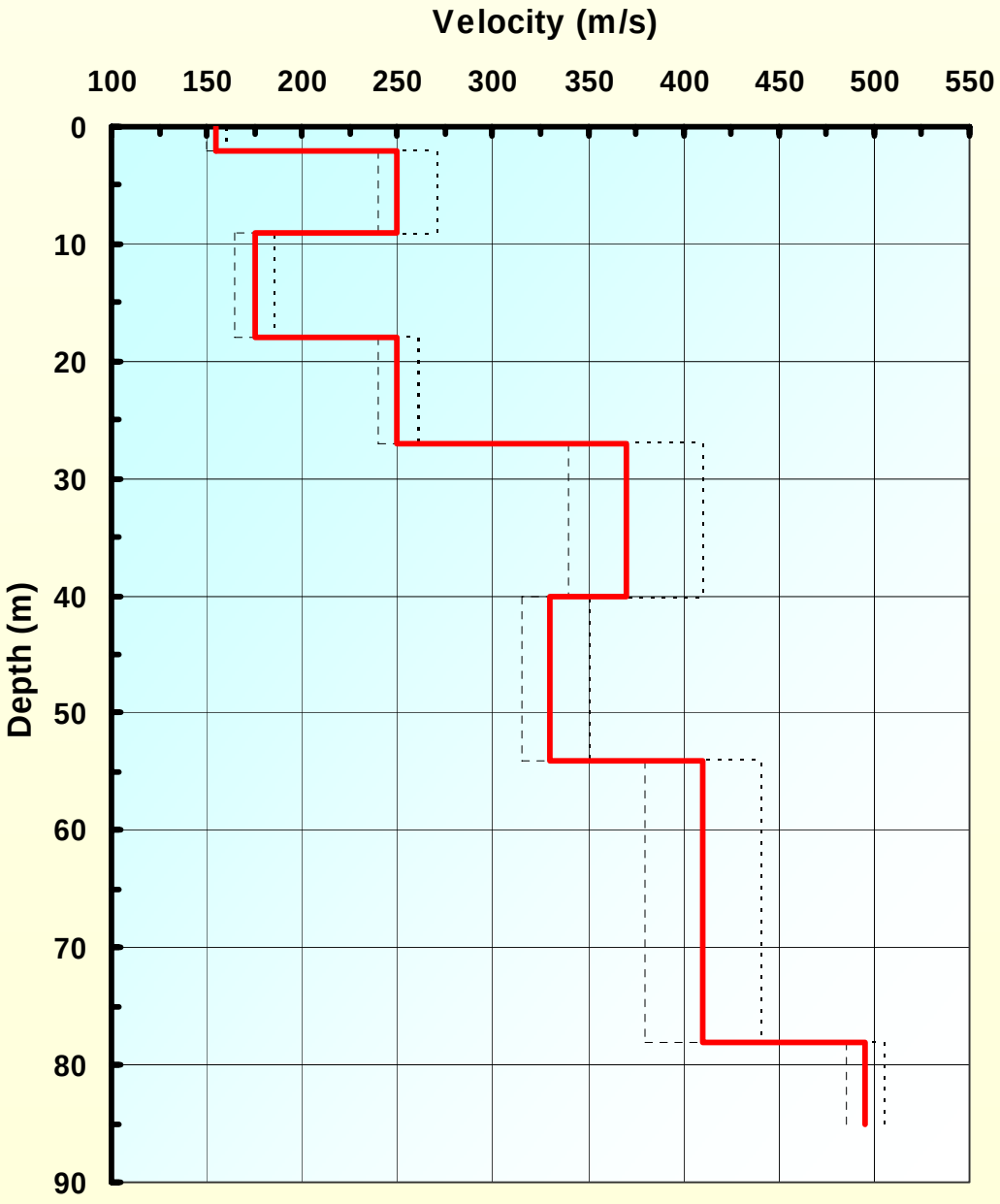
Seismic Reflections and Earthquake Resonances - Cape Girardeau, Missouri

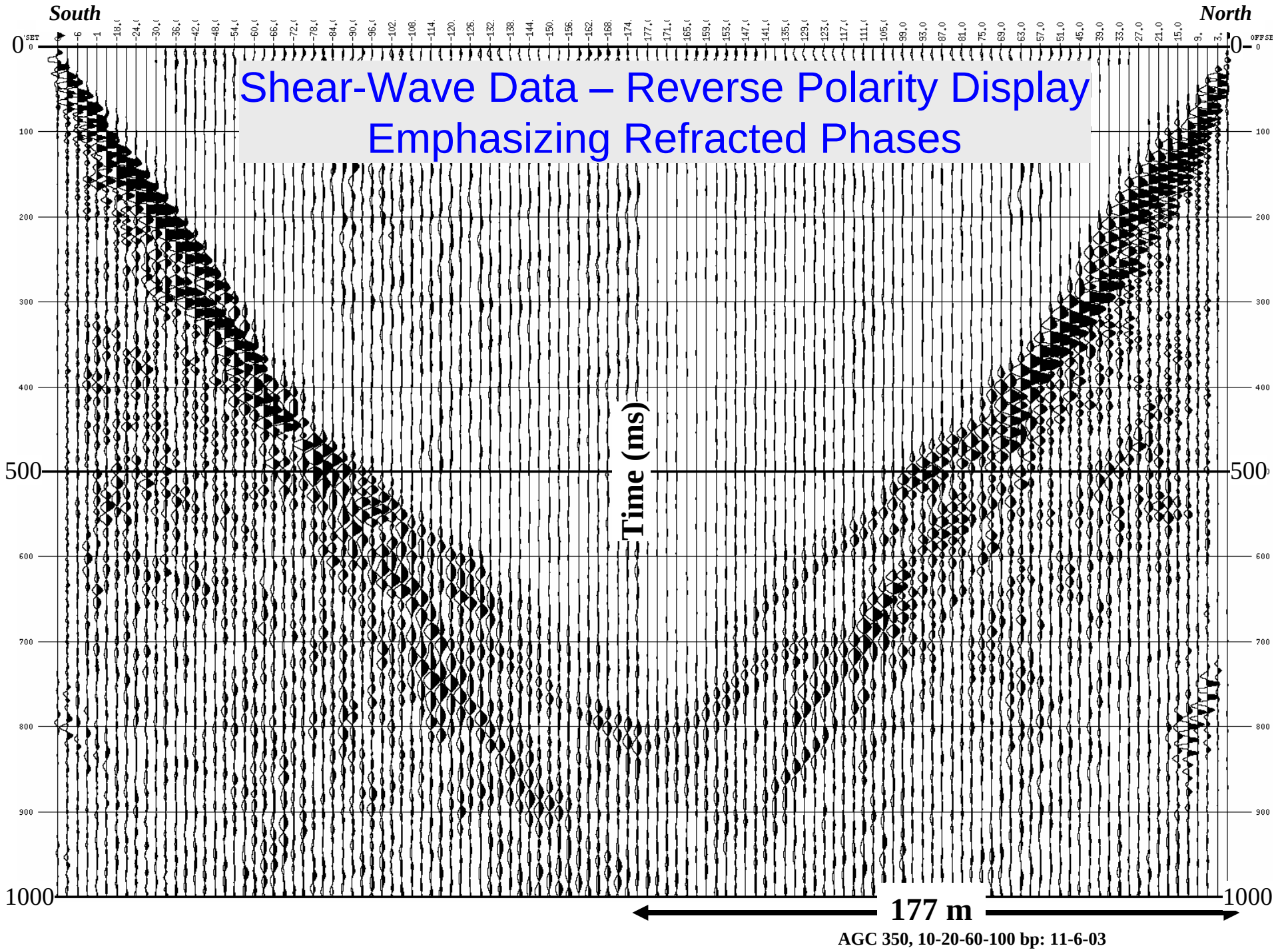
$$f_r = \frac{1}{2T},$$

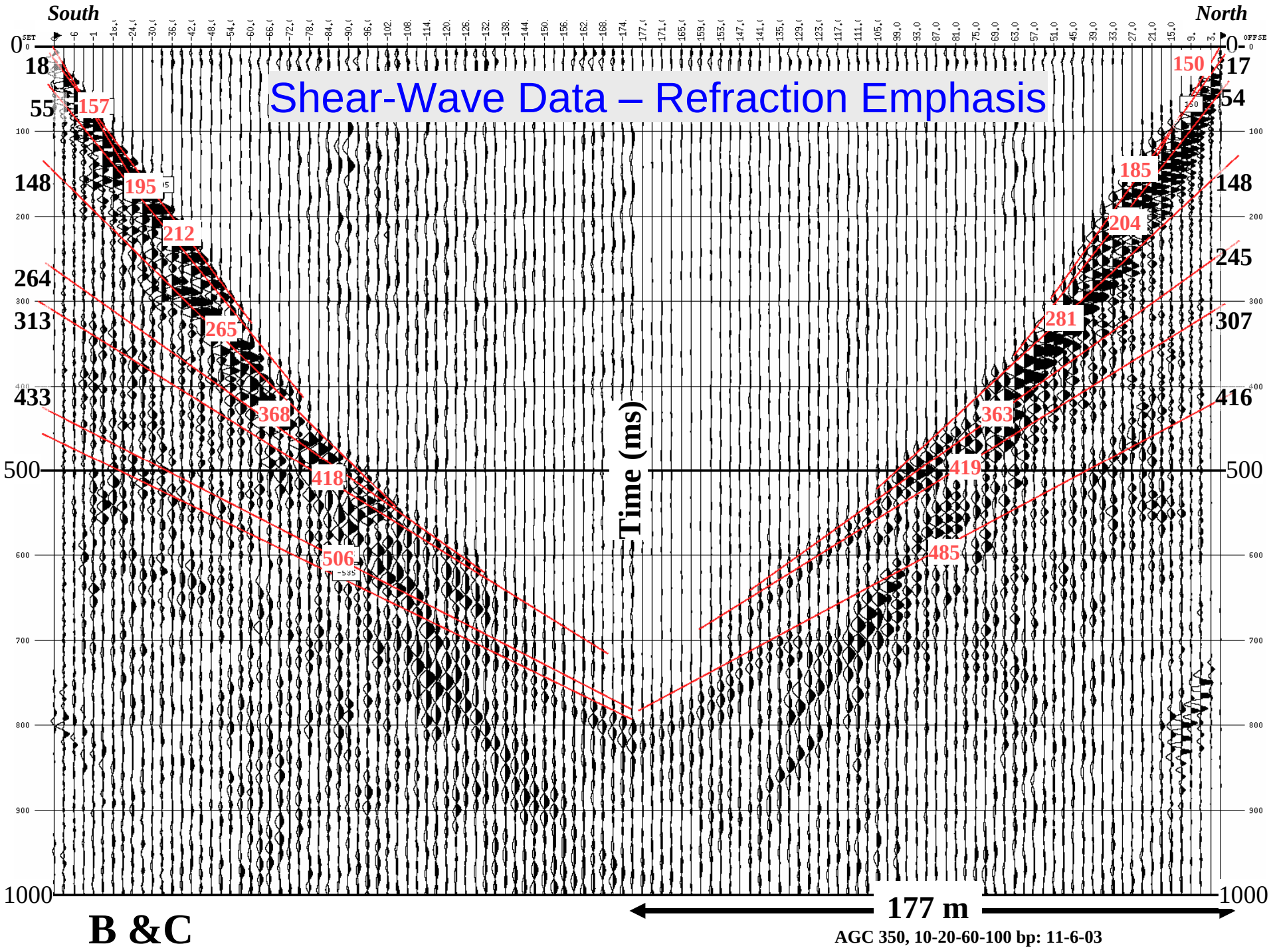
f_r = *resonance freq.*
T = *reflection 2-way travel time*

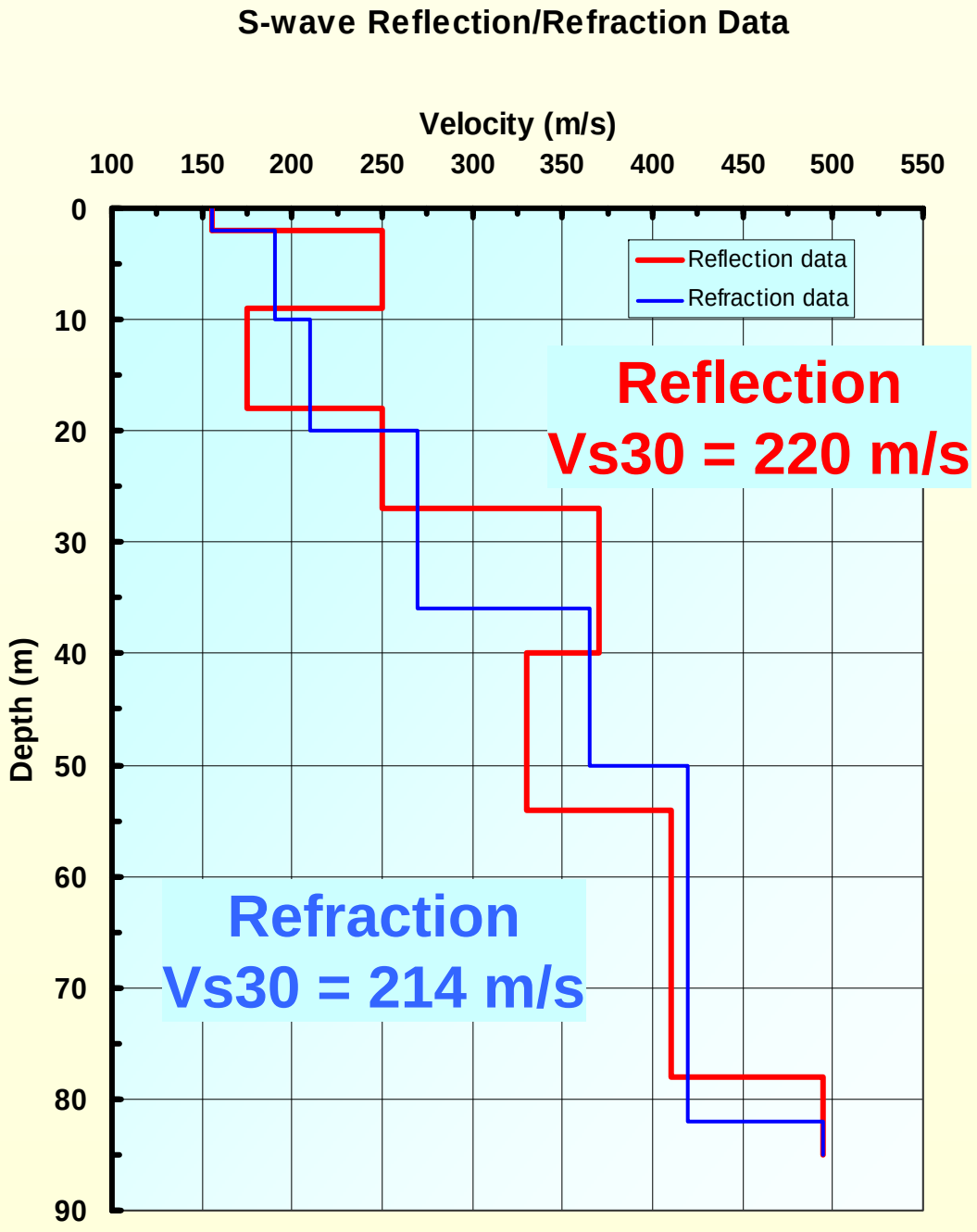


S-wave Reflection/Refraction Data

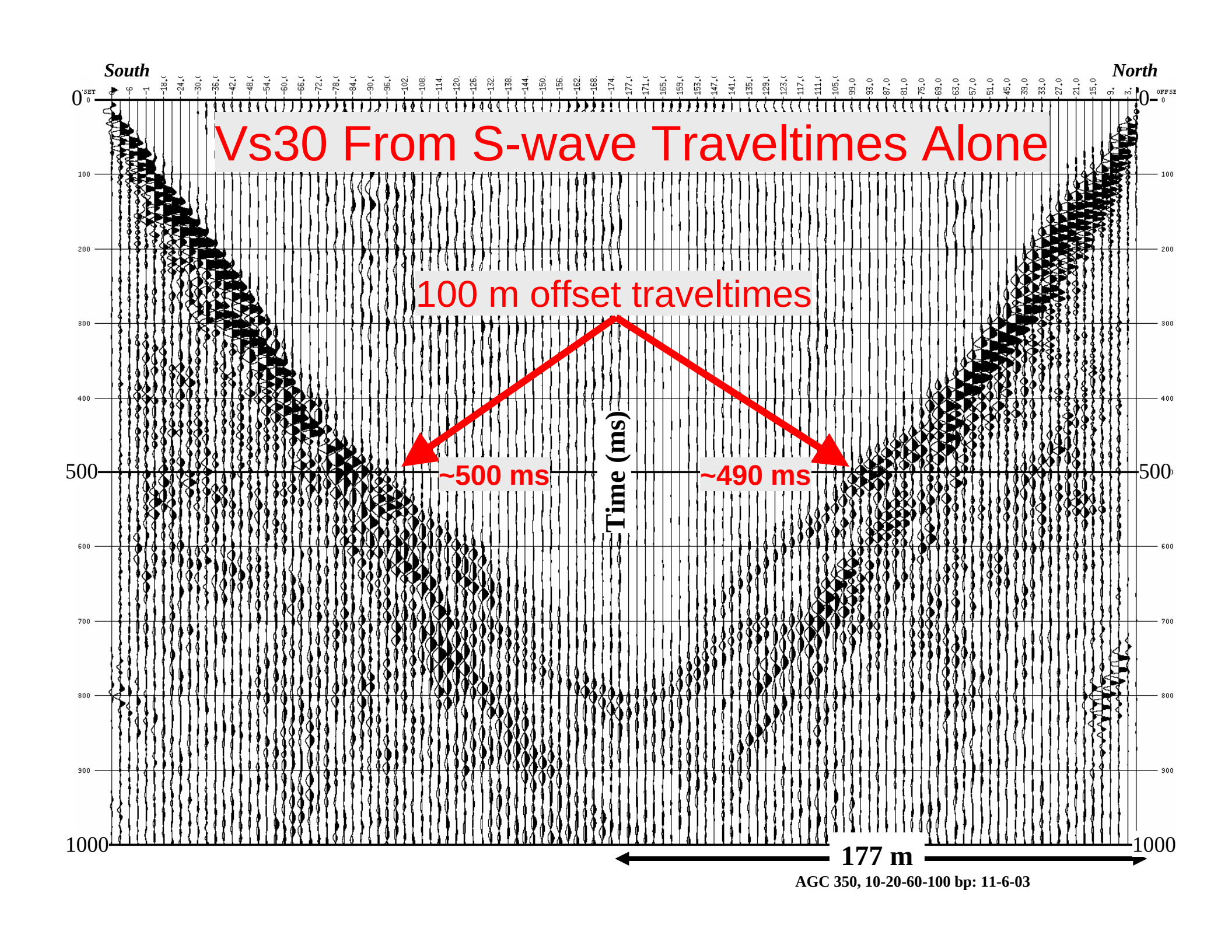



South
North
Shear-Wave Data – Reverse Polarity Display
Emphasizing Refracted Phases
Time (ms)
0
100
200
300
400
500
600
700
800
900
1000
177 m
AGC 350, 10-20-60-100 bp: 11-6-03

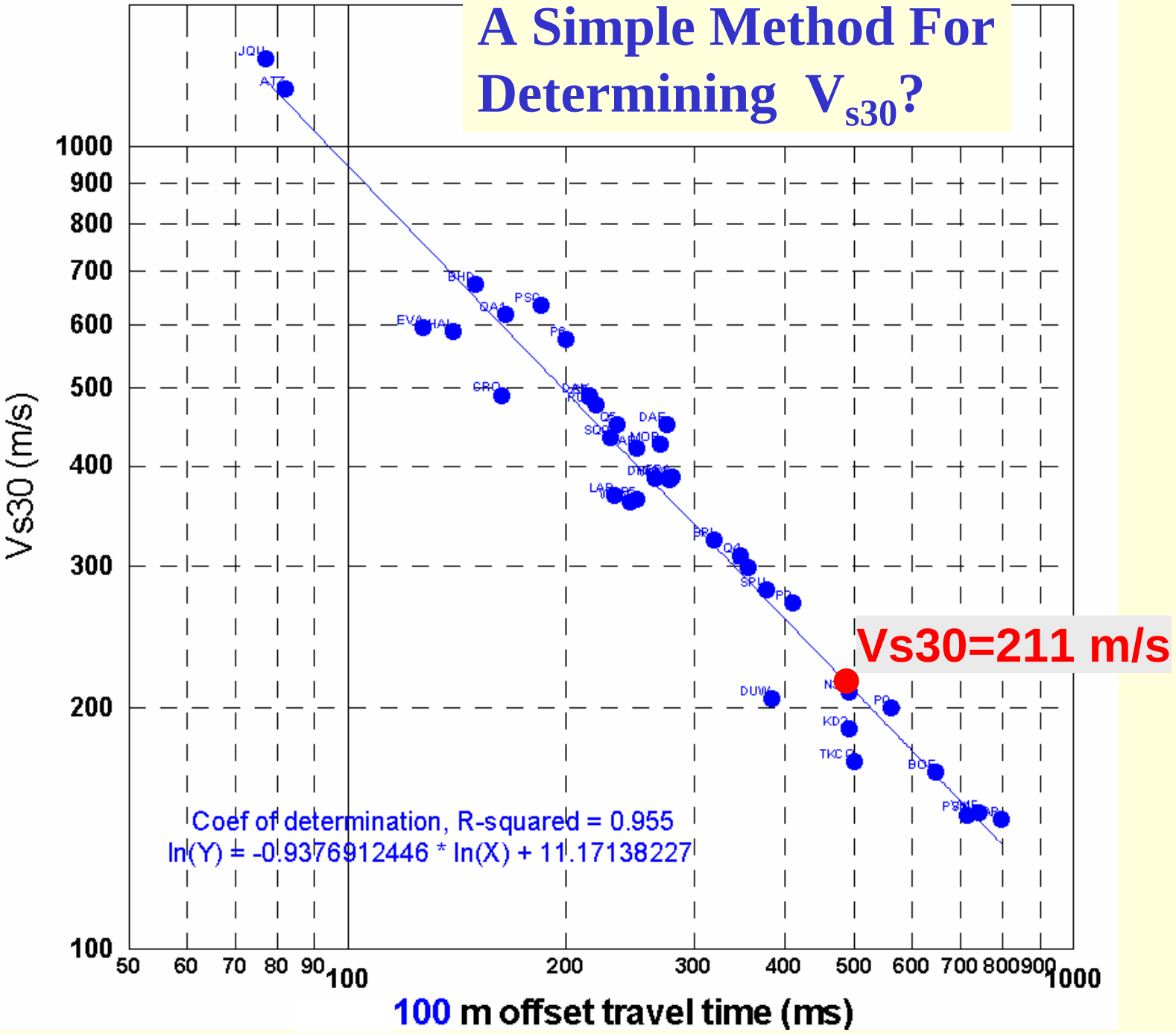

South
North
Shear-Wave Data – Refraction Emphasis
Time (ms)
0
18
55
100
148
200
264
300
313
400
433
500
600
700
800
900
1000
157
195
212
265
368
418
506
150
185
204
281
363
419
485
177 m
B &C
AGC 350, 10-20-60-100 bp: 11-6-03

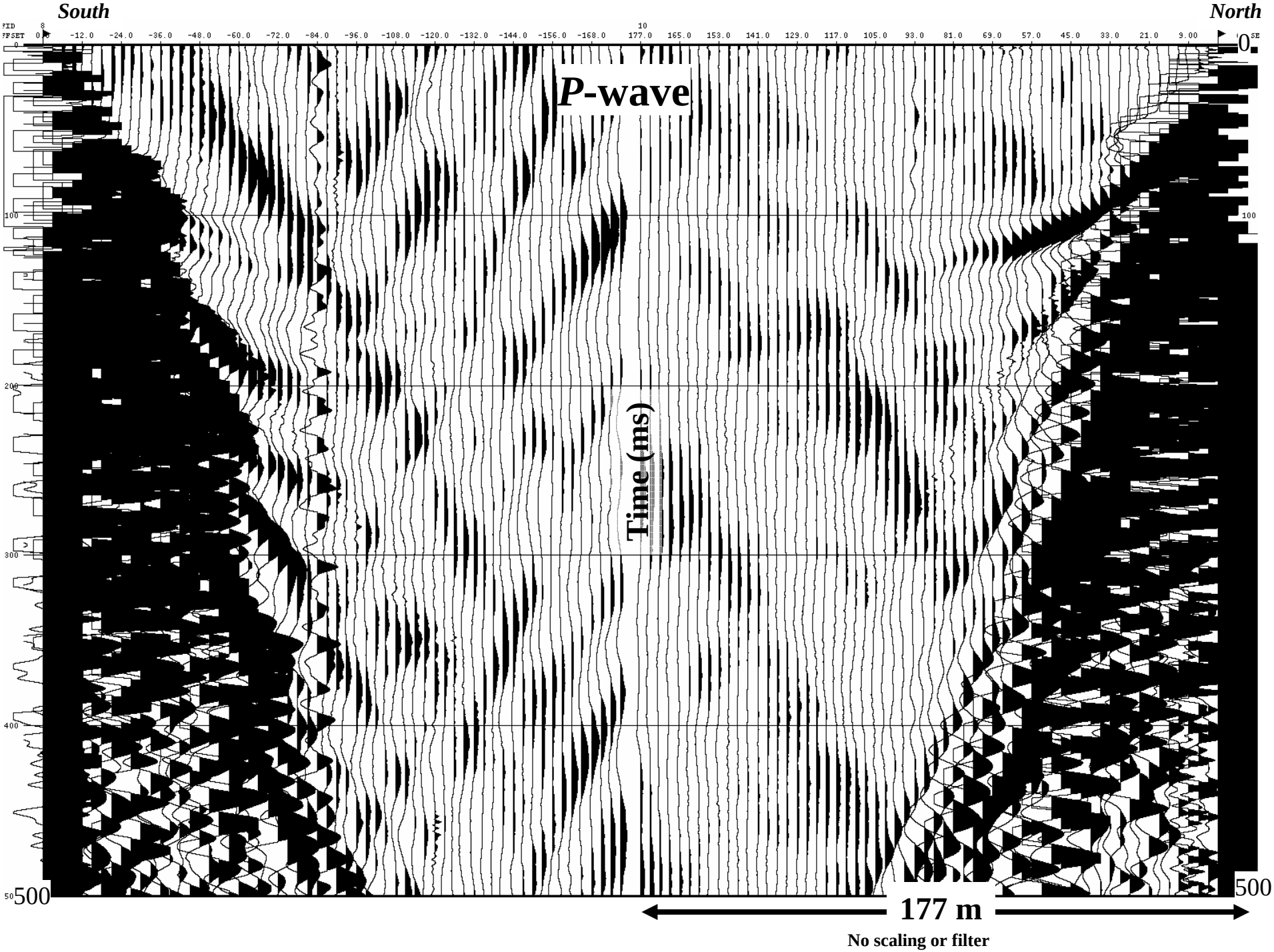


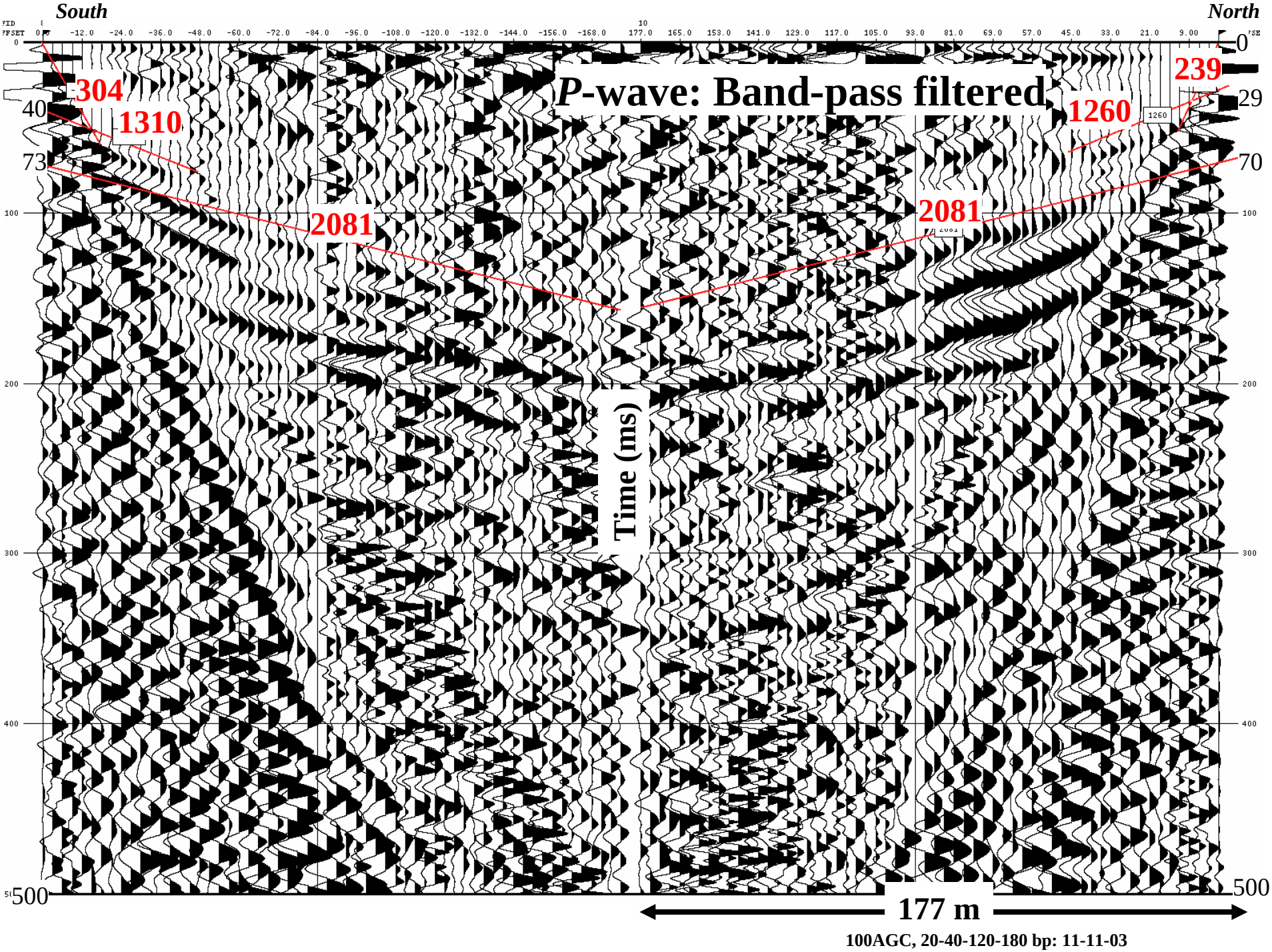
- Technique has been found to be a good estimator of Vs30.
- Generally will not have as many layers as downhole or suspension log.
- Useful for detecting primary impedance boundaries that may generate damaging resonances during earthquakes.

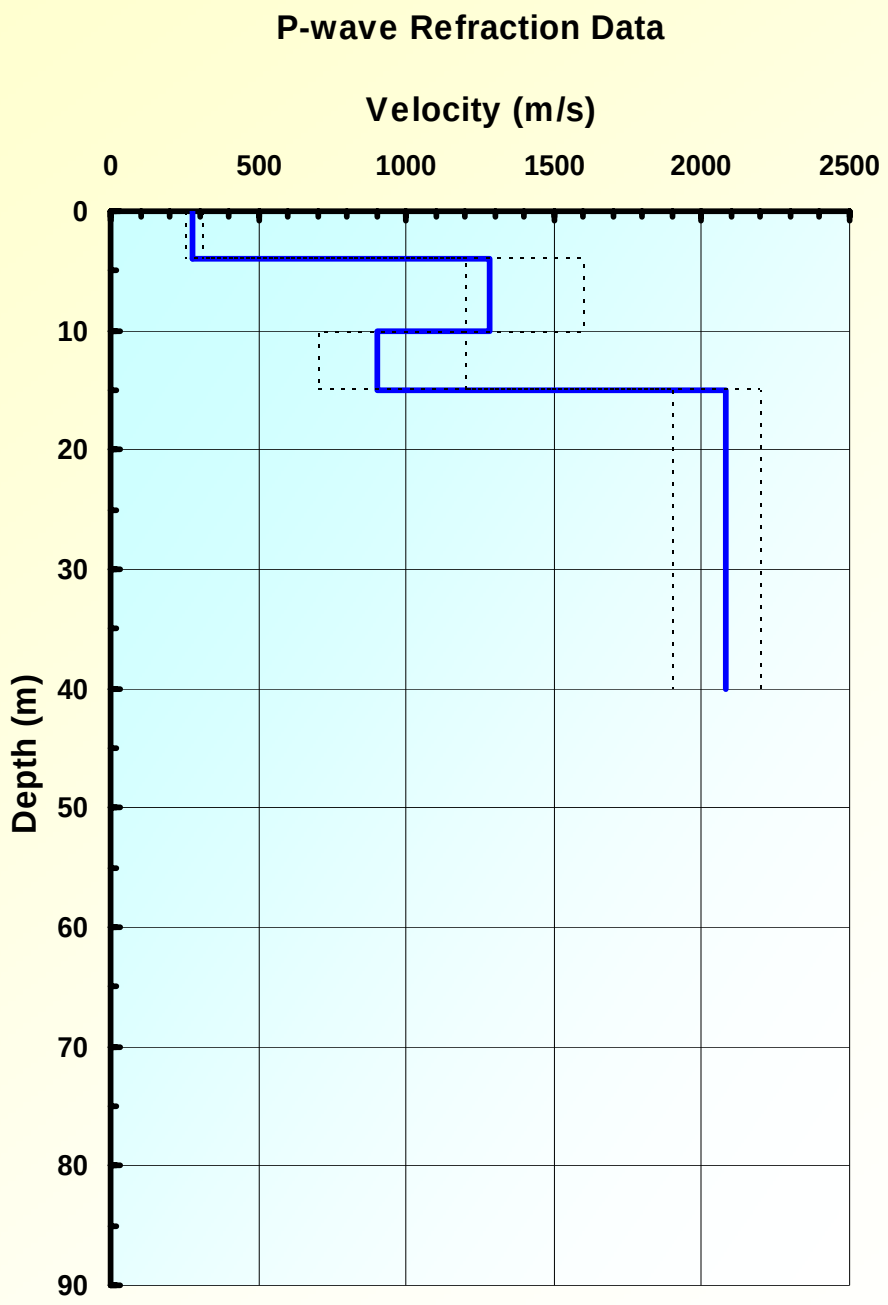

South
North
Vs30 From S-wave Traveltimes Alone
100 m offset traveltimes
~500 ms
~490 ms
Time (ms)
177 m
AGC 350, 10-20-60-100 bp: 11-6-03

A Simple Method For Determining V_{s30}?




South
North
P-wave
Time (ms)
177 m
No scaling or filter


South
North
P-wave: Band-pass filtered
304
1310
2081
239
1260
2081
Time (ms)
177 m
100AGC, 20-40-120-180 bp: 11-11-03

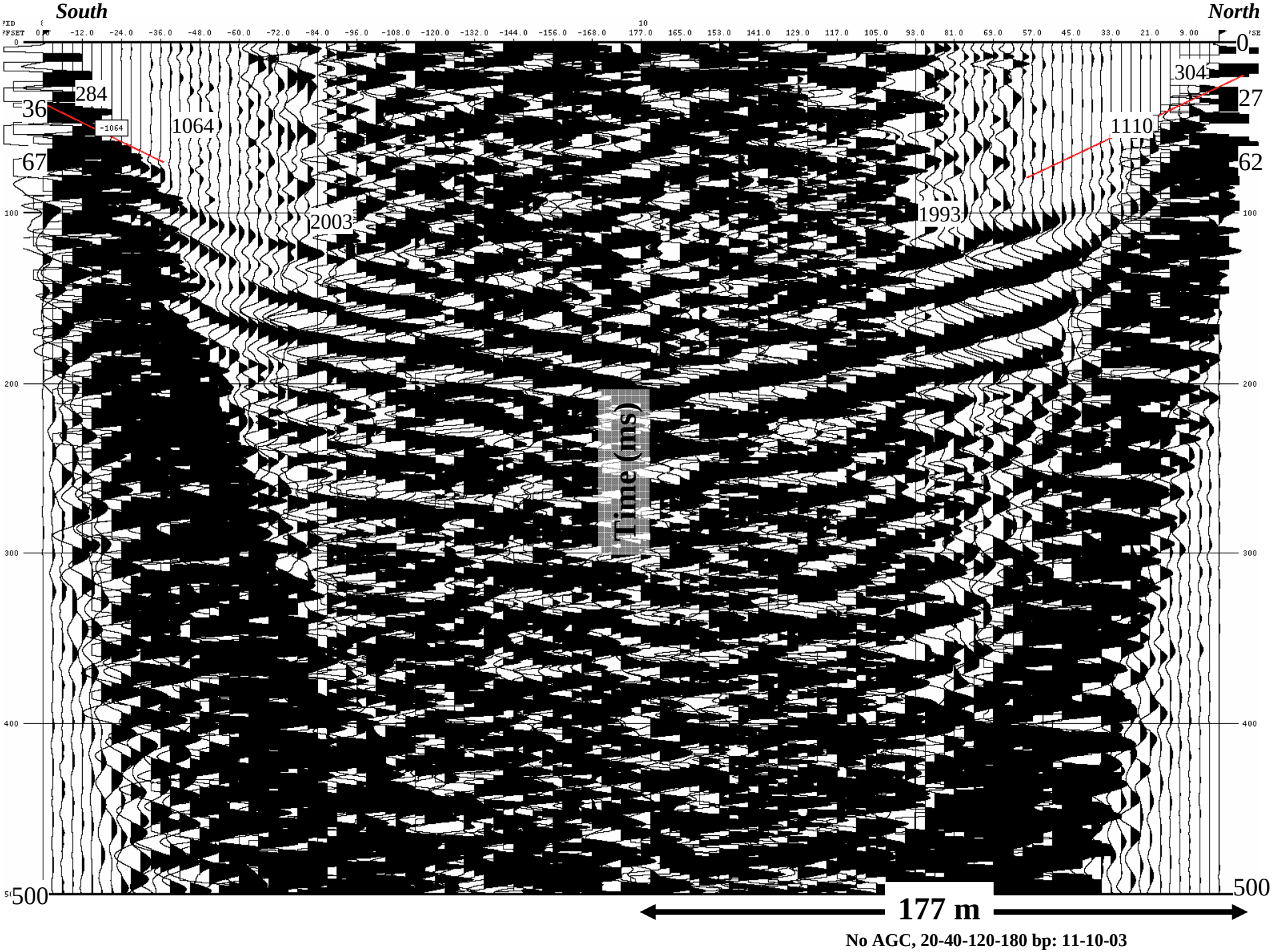

P-wave Refraction Data
Velocity (m/s)
0
500
1000
1500
2000
2500
Depth (m)
0
10
20
30
40
50
60
70
80
90

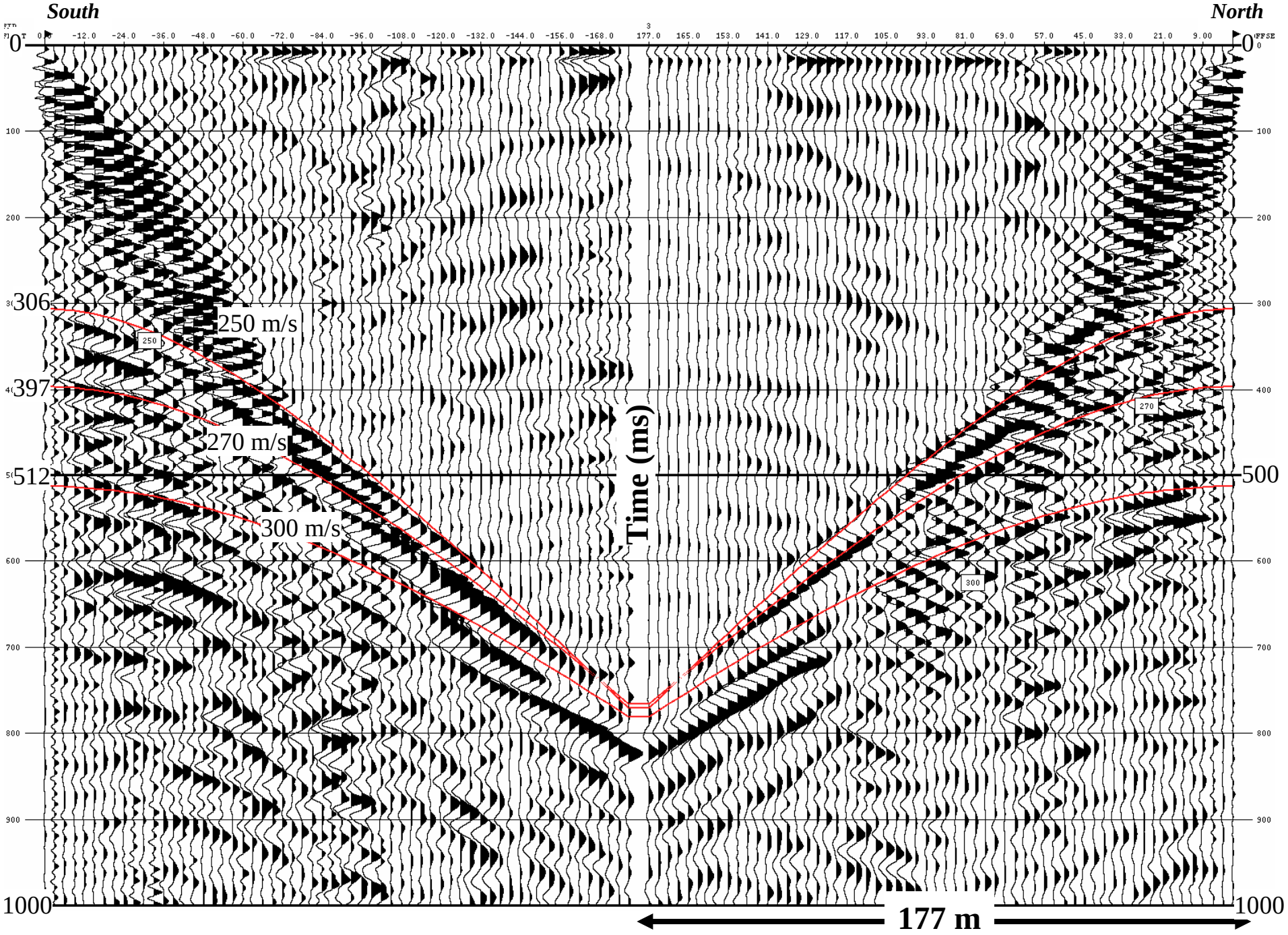
Conclusions: Surface seismic-reflection/refraction data:

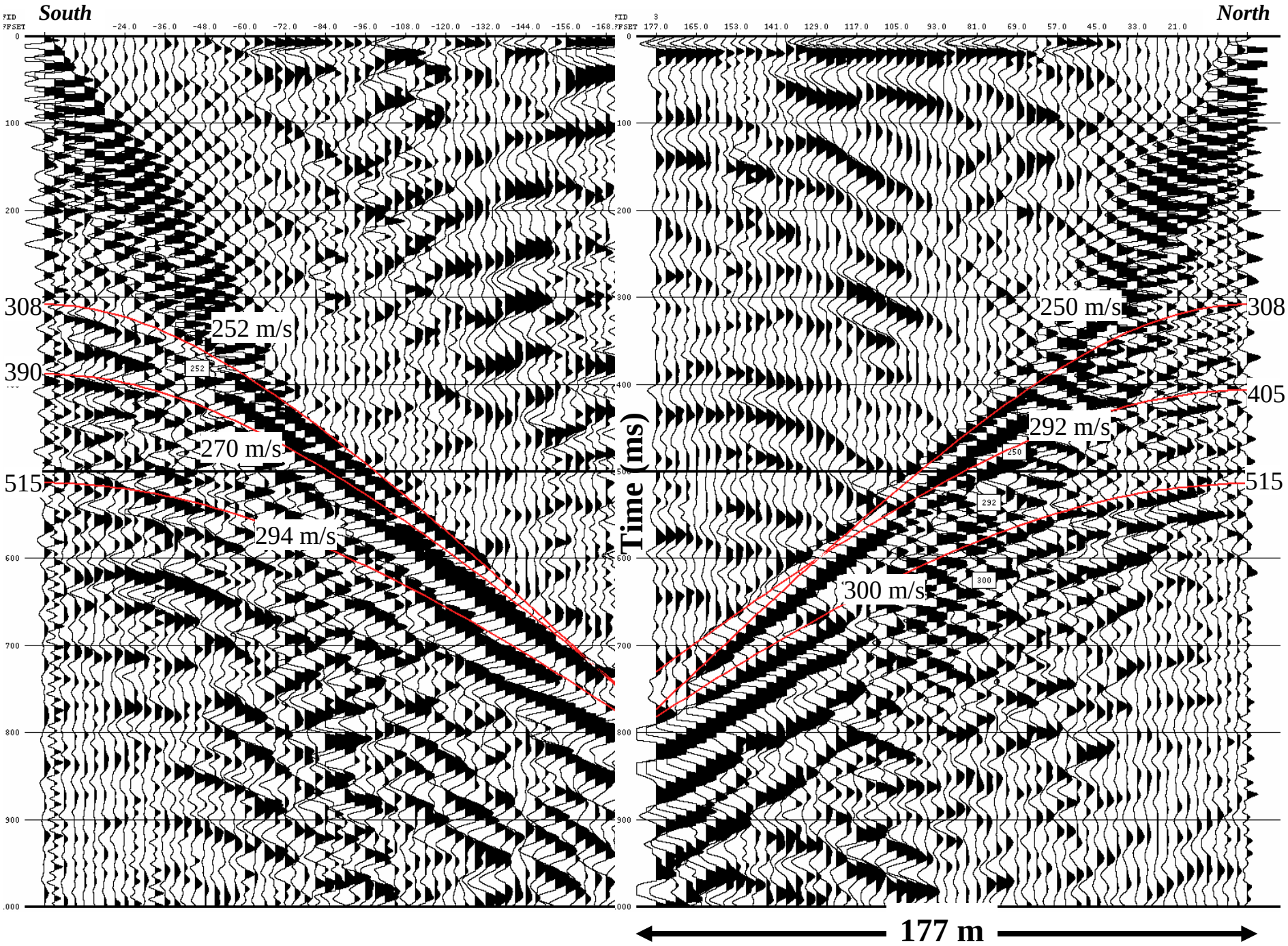
- Are a fast, non-invasive, and inexpensive alternative for the 0-75 m depth range
- May be a better representation of the true impedance structure than other non-invasive procedures
- Show that imaged reflections can indicate frequencies of site resonances
- Show that refraction-phase travel time at 100 m is a simple way to measure Vs30
- Indicate the need for inexpensive deeper imaging (100-300 m) to get V_S in urban areas located on sedimentary basins

Conclusions: ReMi and MASW Methods

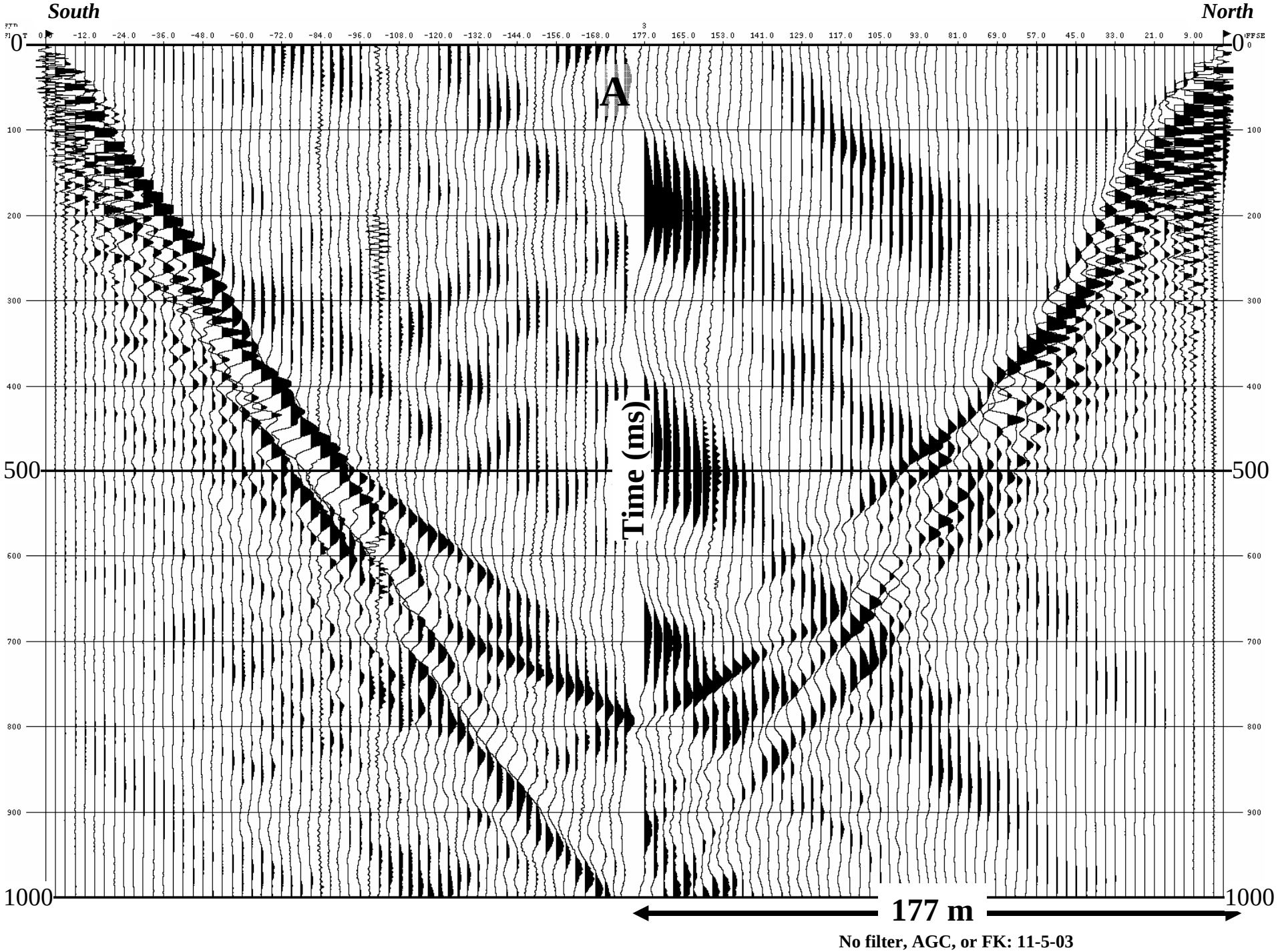
- **ReMi and MASW are a fast, non-invasive, and inexpensive alternative, *with* ReMi *having a very low impact on urban/suburban environment***
- **ReMi and MASW Generally allow for deeper imaging than reflection and refraction data given the same work area and a <4.5-Hz sensor**
- **Not as true a representation of the impedance structure?**
- **May have limited application in a thin layer-over-a-halfspace situation**

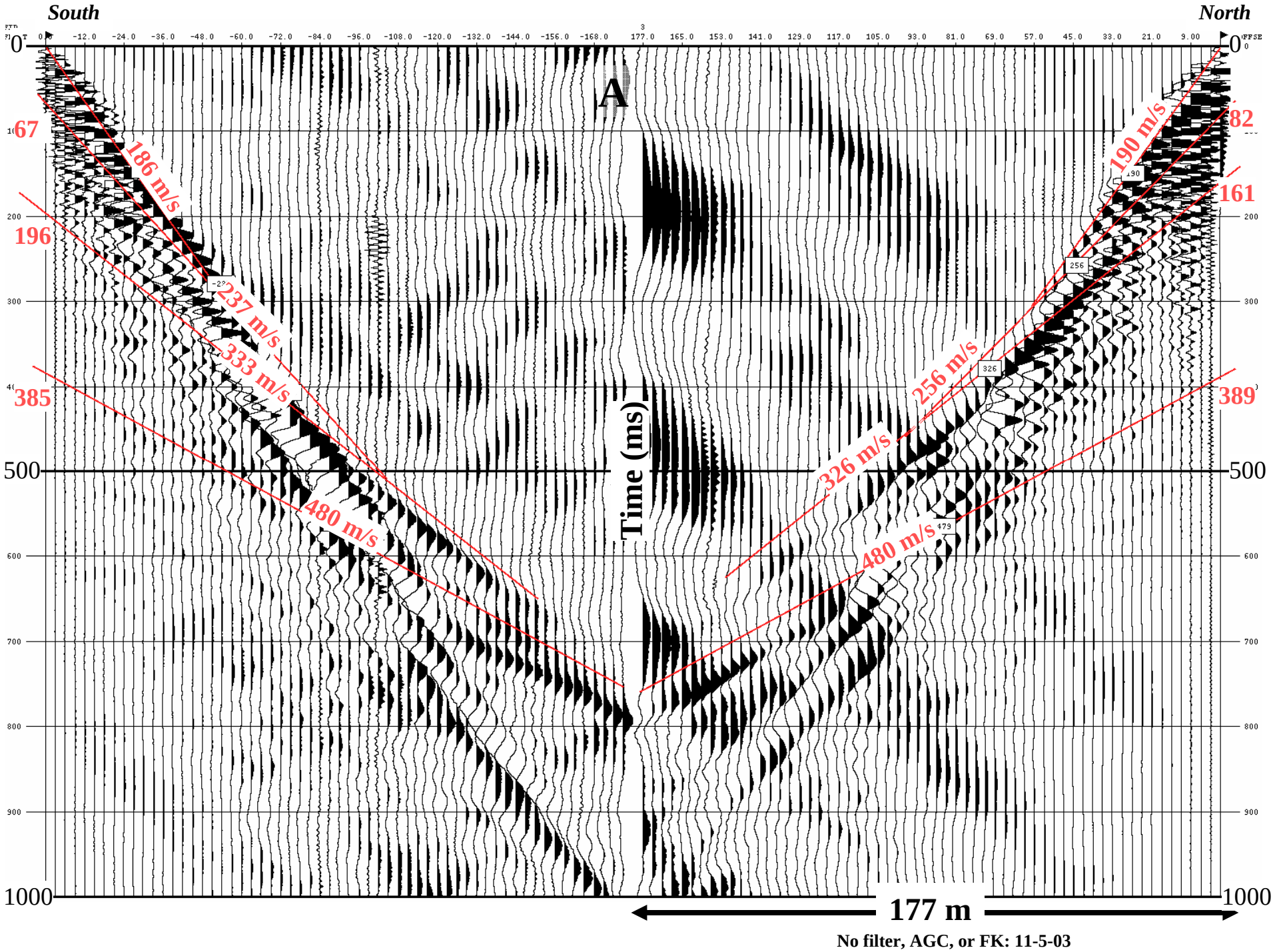

South
North
284
36
-1064
1064
67
2003
1993
1110
304
27
62
0
100
200
300
400
500
Time (ms)
177 m
No AGC, 20-40-120-180 bp: 11-10-03

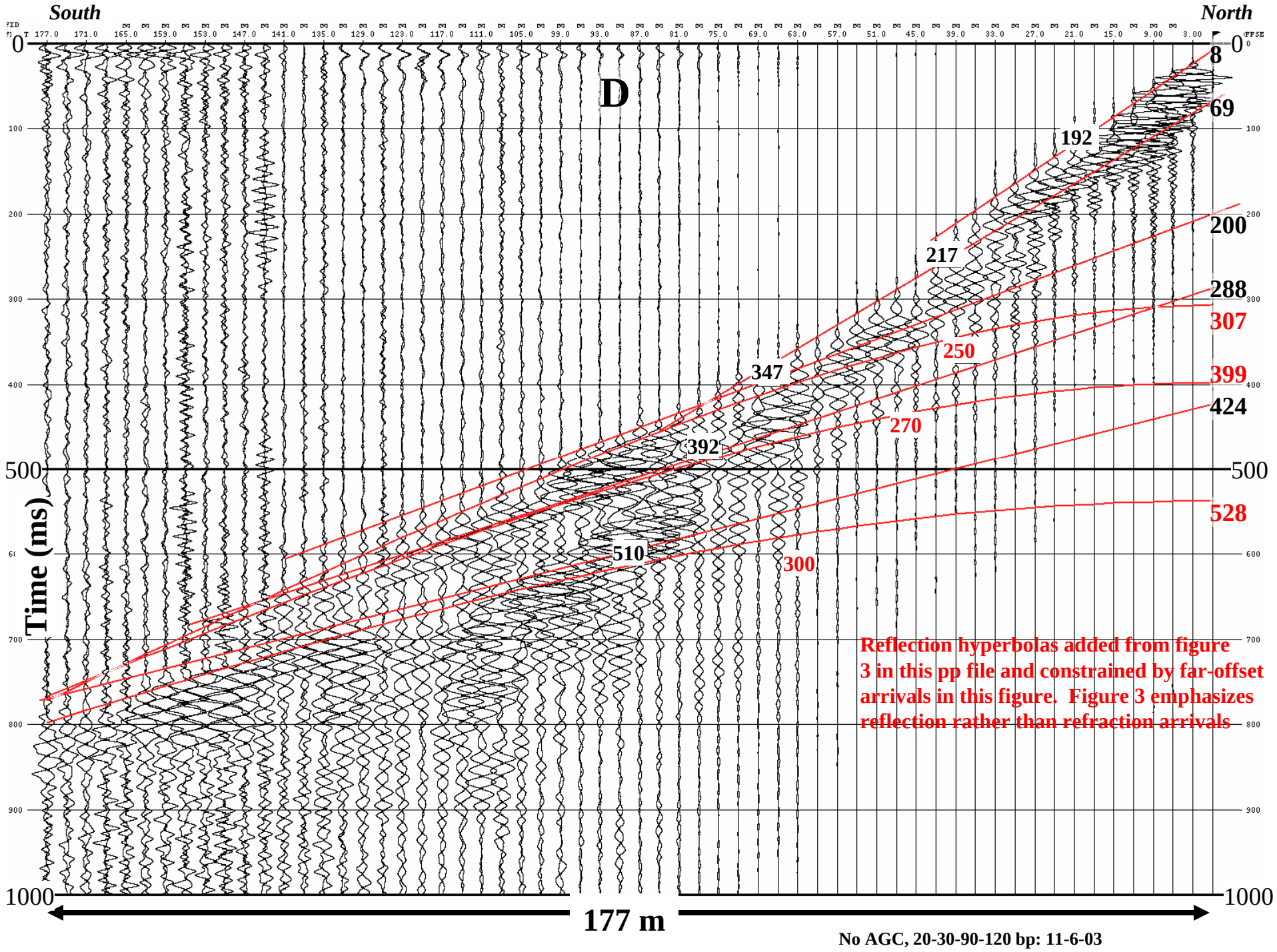

South
North
0
306
397
512
1000
250 m/s
270 m/s
300 m/s
Time (ms)
177 m
AGC 350, 10-20-60-100 bp, FK -300-300 m/s: 11-5-03

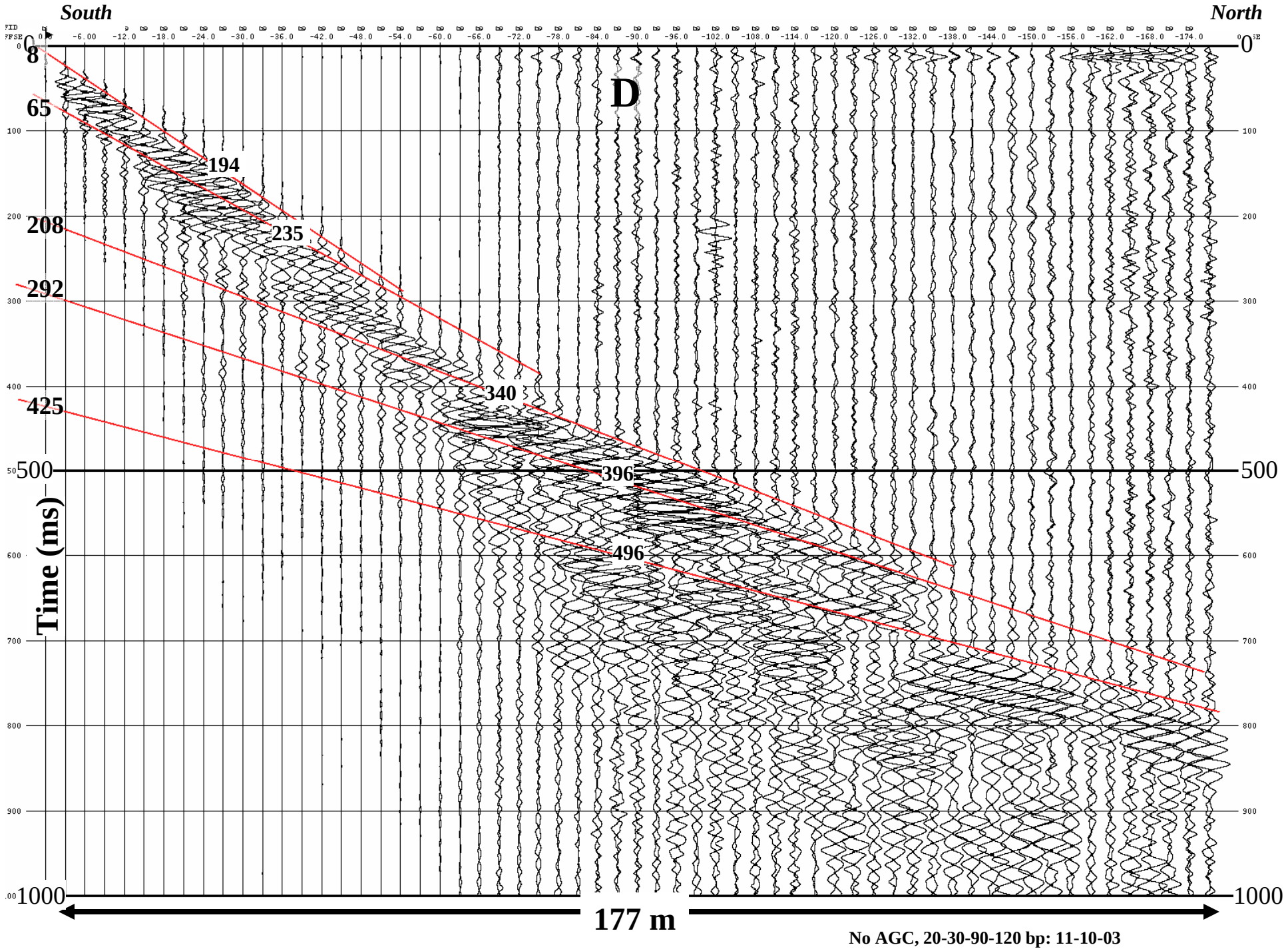


AGC 350, 10-20-60-100 bp, FK -300-300 m/s: 11-5-03


South
North
A
Time (ms)
0
100
200
300
400
500
600
700
800
900
1000
177 m
No filter, AGC, or FK: 11-5-03


South
North
A
Time (ms)
67
186 m/s
196
237 m/s
333 m/s
385
480 m/s
82
190 m/s
161
256 m/s
326 m/s
389
480 m/s
177 m
No filter, AGC, or FK: 11-5-03


South
North
D
Time (ms)
0
100
200
300
400
500
600
700
800
900
1000
8
69
192
200
217
288
307
250
399
347
424
270
392
528
510
300
Reflection hyperbolas added from figure 3 in this pp file and constrained by far-offset arrivals in this figure. Figure 3 emphasizes reflection rather than refraction arrivals
177 m
No AGC, 20-30-90-120 bp: 11-6-03


South
North
D
8
65
194
208
235
292
340
425
396
496
Time (ms)
0
500
1000
177 m
No AGC, 20-30-90-120 bp: 11-10-03