Reflection seismic

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Now tool for (non petroleum) geologist

- Up to 90 th, reflection was (only) used for oil prospecting for economic reasons
- This method became much more affordable for water, geotechnical investigations
- New digital seismograph
- Powerful personal computer
- Inexpensive processing software

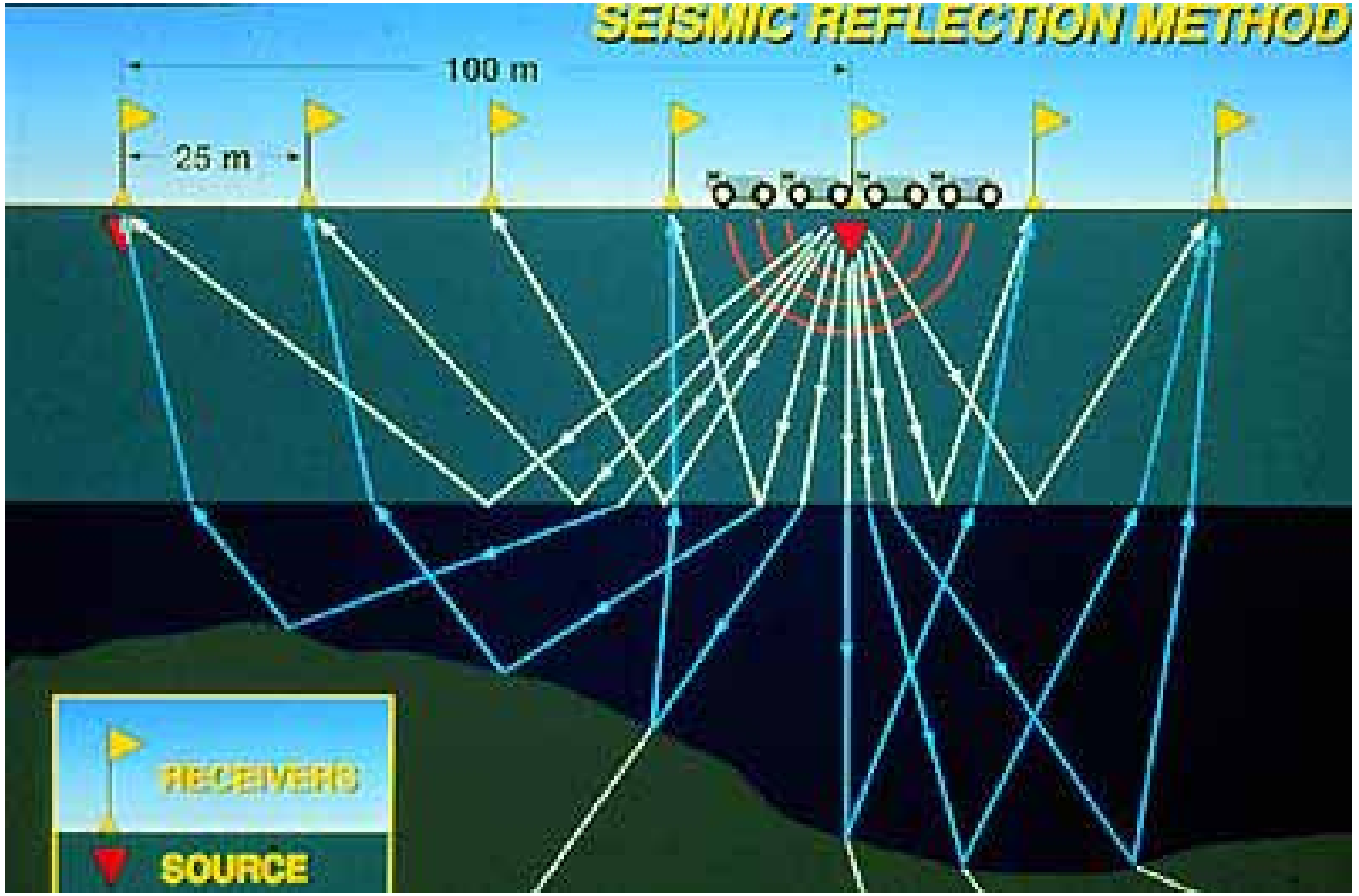
Reflexion seismic usual applications

- Oil (From 1920 th)
- Deep water prospecting
- Deep geotechnical investigation
- High velocity layer on surface

Summary

- **Principle**
- **Equipment**
- **Processing**
- **Examples**

Principle



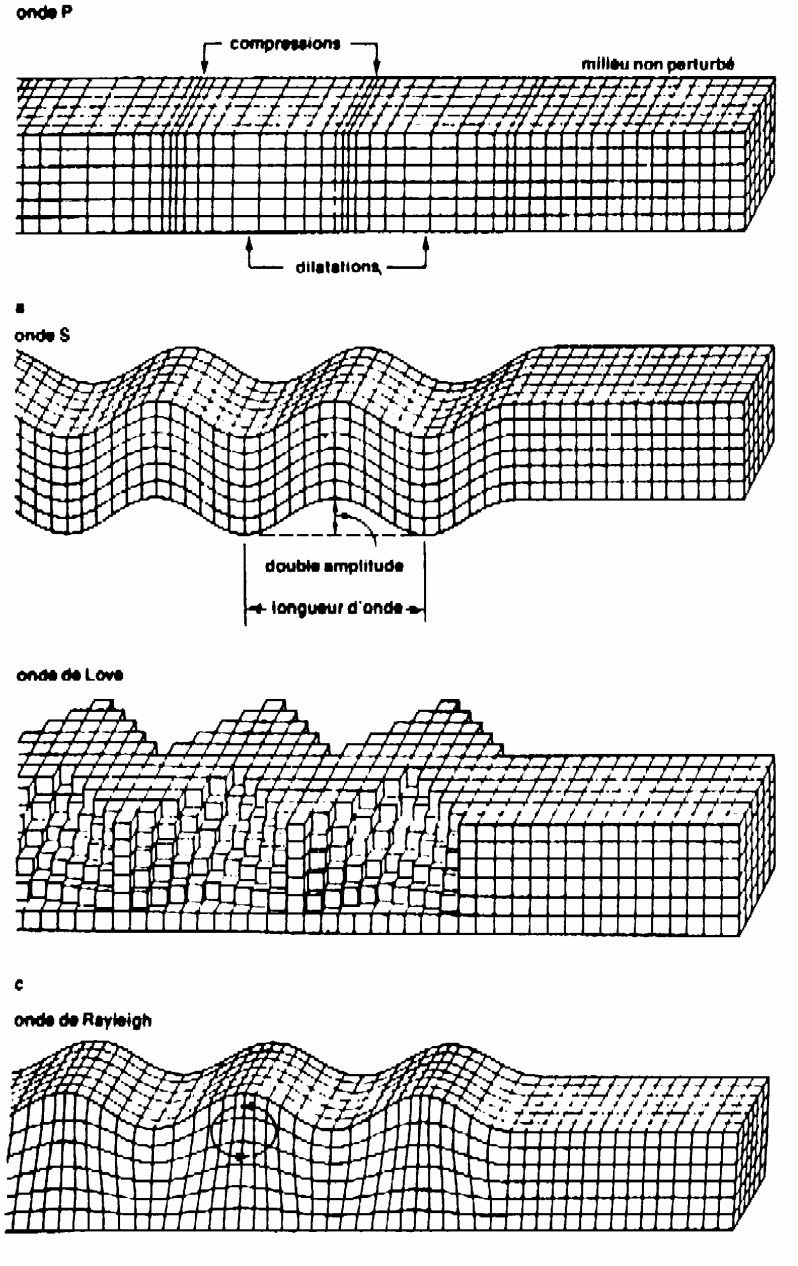
Seismic waves

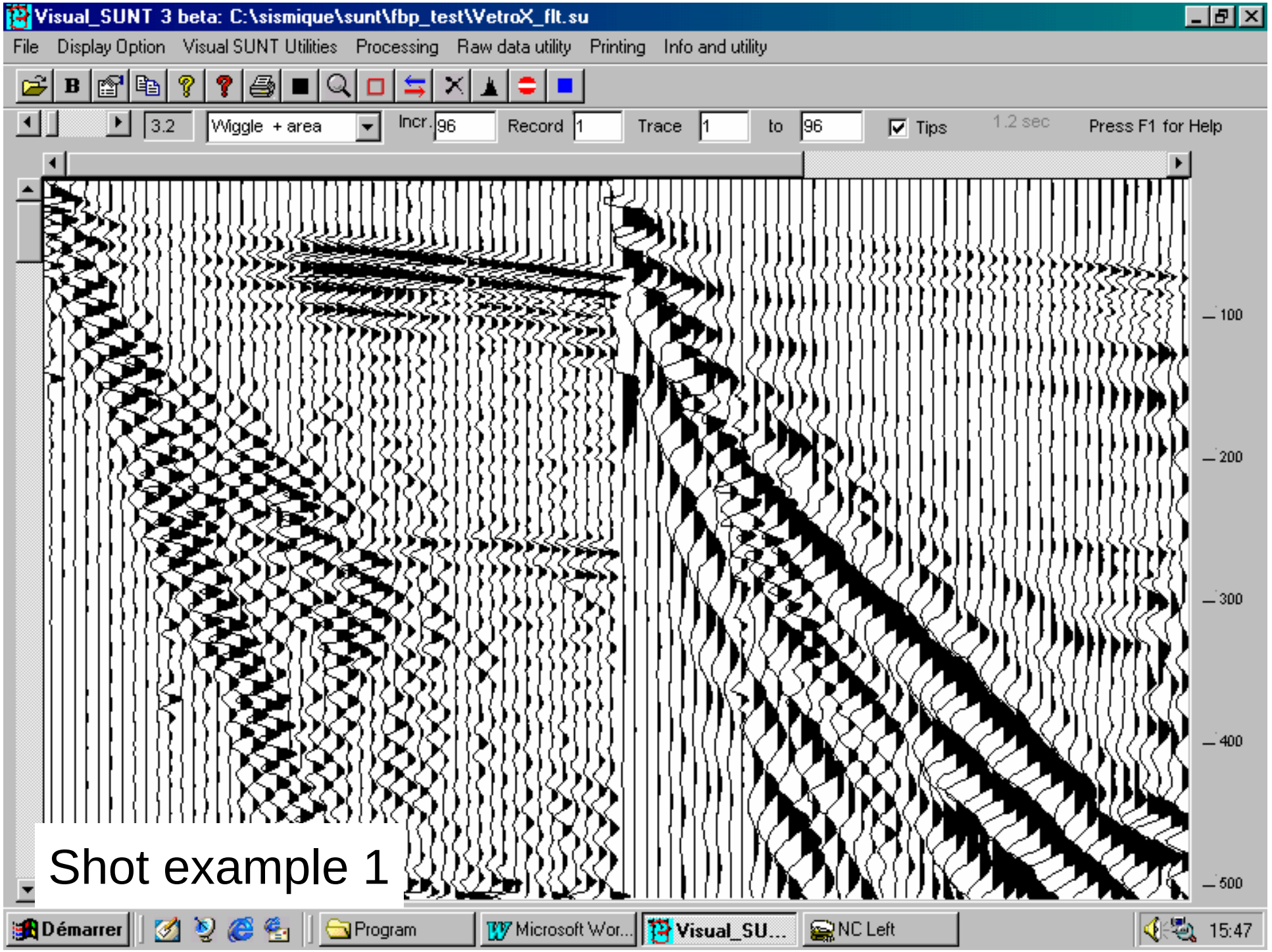
Body

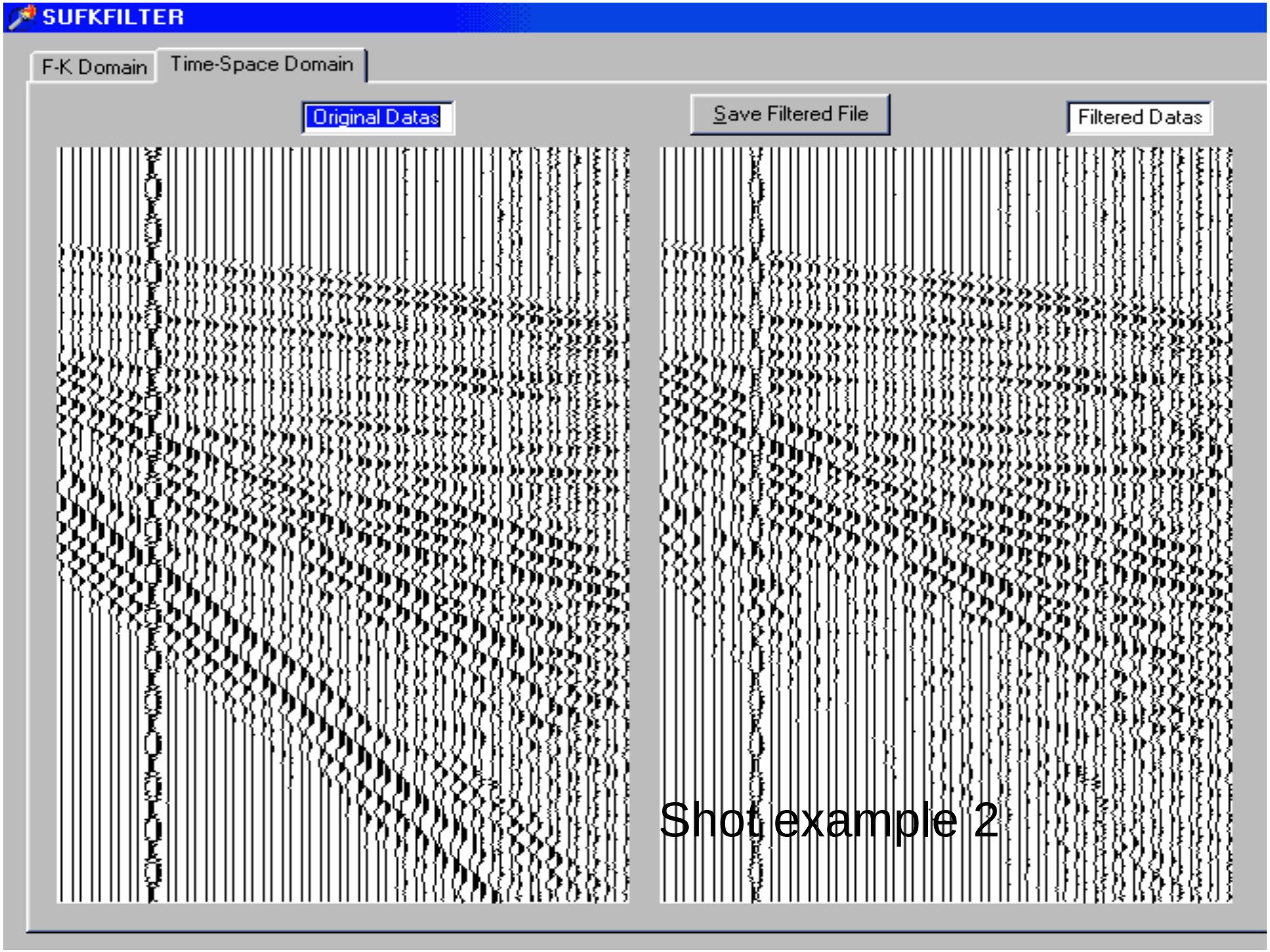
P

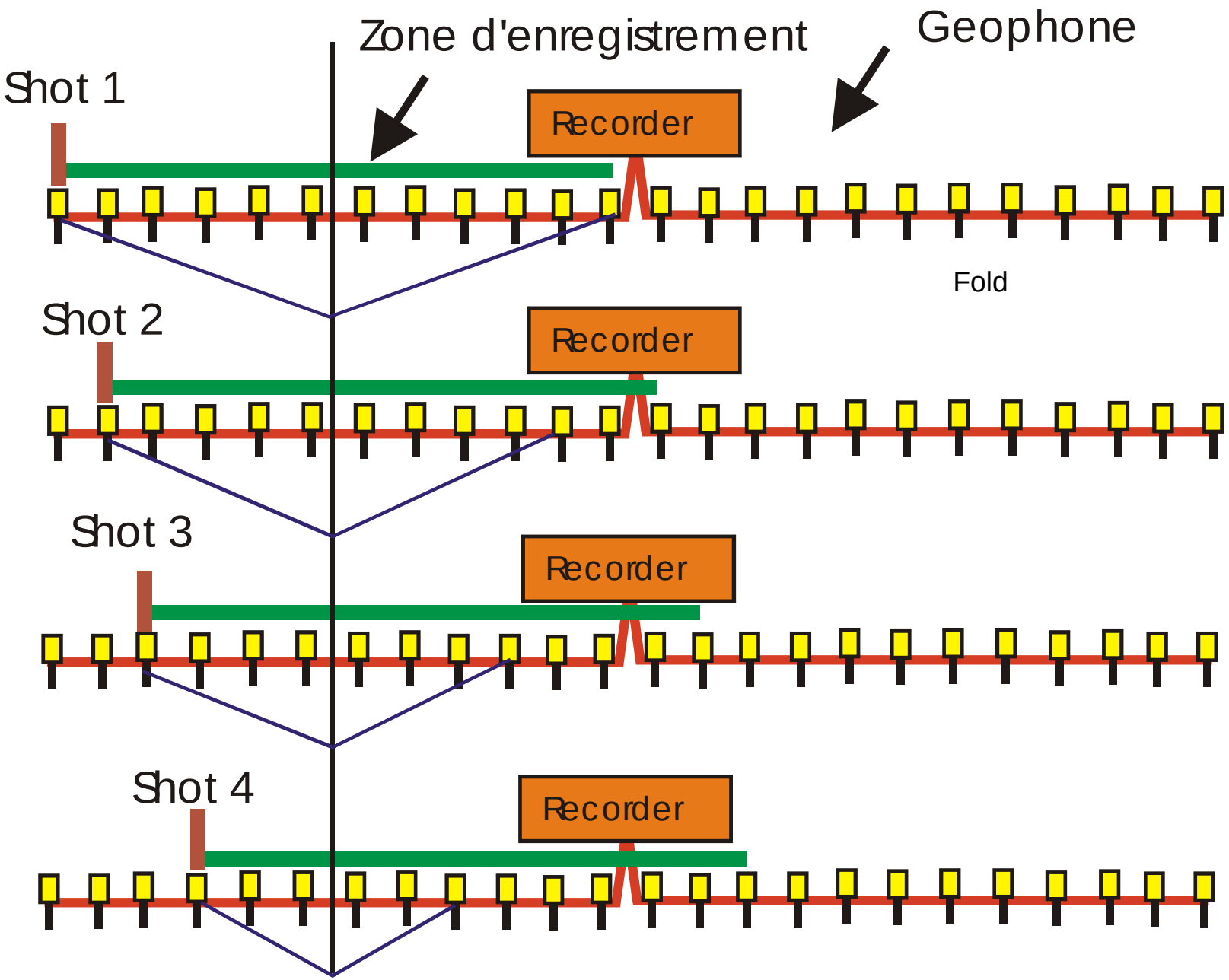
S

Surface

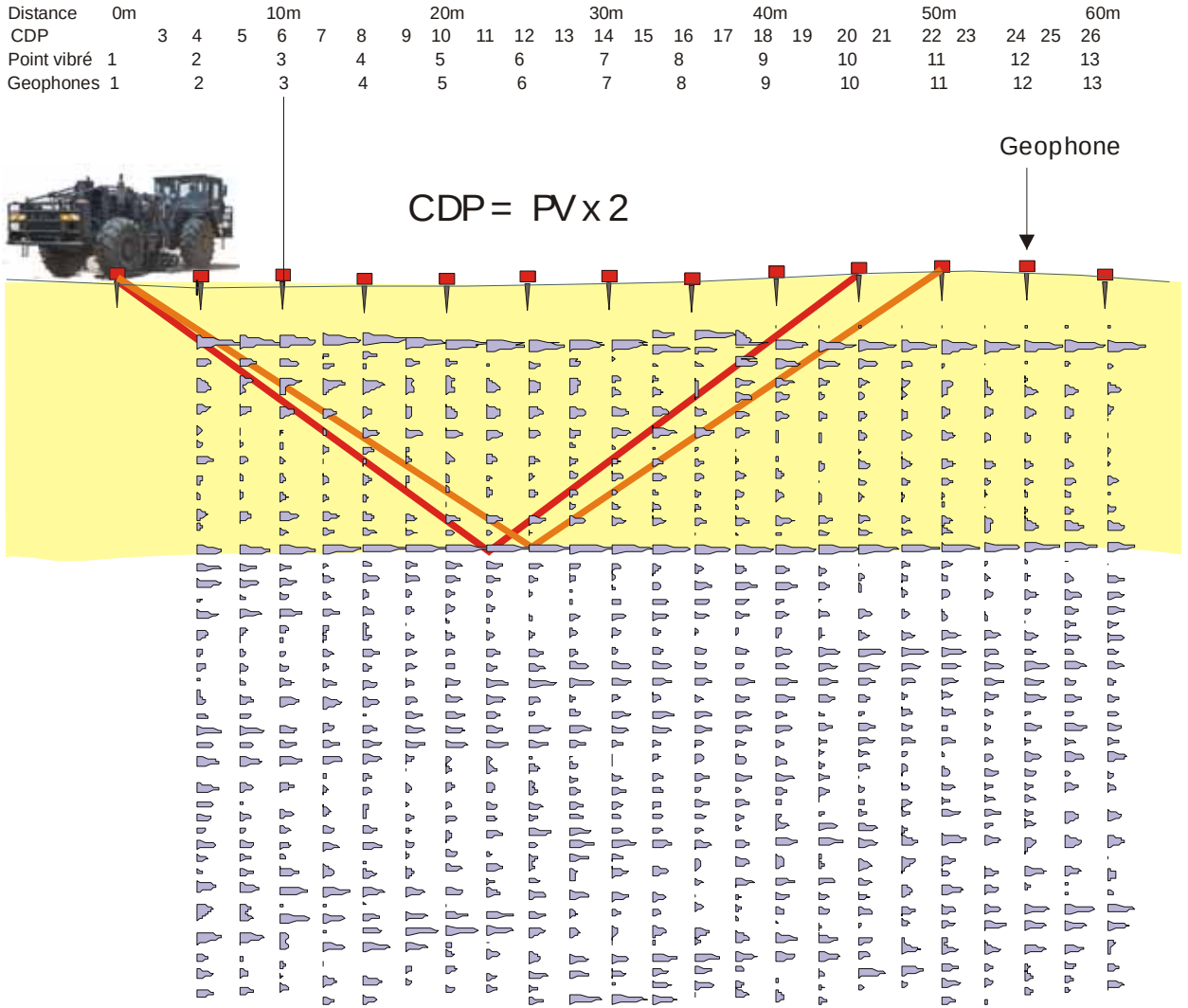



Visual_SUNT 3 beta: C:\sismique\sunt\fbp_test\VetroX_flt.su
File
Display Option
Visual SUNT Utilities
Processing
Raw data utility
Printing
Info and utility
3.2
Wiggle + area
Incr.
96
Record
1
Trace
1
to
96
Tips
1.2 sec
Press F1 for Help
100
200
300
400
500
Shot example 1
Démarrer
Program
Microsoft Wor...
Visual_SU...
NC Left
15:47

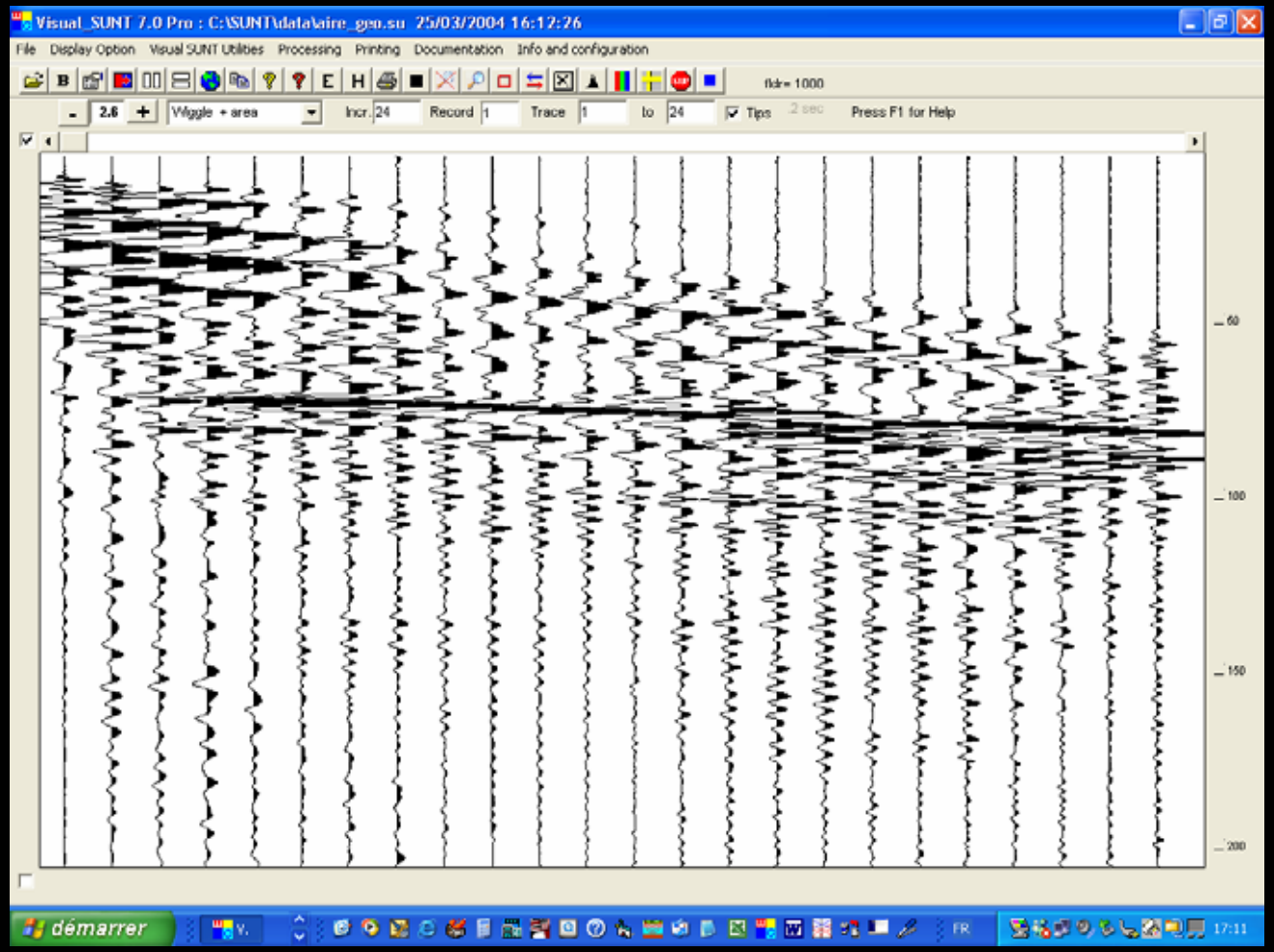

SUFKFILTER
F-K Domain
Time-Space Domain
Original Datas
Save Filtered File
Filtered Datas
Shot example 2


Zone d'enregistrement
Geophone
Shot 1
Recorder
Fold
Shot 2
Recorder
Shot 3
Recorder
Shot 4
Recorder

CDP


Distance 0m 10m 20m 30m 40m 50m 60m
CDP 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Point vibré 1 2 3 4 5 6 7 8 9 10 11 12 13
Geophones 1 2 3 4 5 6 7 8 9 10 11 12 13
Geophone
CDP = PV x 2

Example of field record



Reflection VS refraction

- + Depth of investigation
- + Complex geology
- + Velocity inversion
- - Complex
- - Cost, equipment
- - Processing

Equipment

- **Geophones**
- **Seismic cables**
- **Seismograph**
- **Roll along**
- **Energy source**

Geophones


string
Geophone string

Seismic cables

Usually CDP cables
including extension cables
Heavy and delicate equipment …

Seismograph

24 – 120 channels
Digital
Reliable
Screen control
(Autocorrelation)

Roll along & seismograph

Source

- Sledge Hammer
- Drop weight
- Explosives
- Buffalo gun
- Vibrator

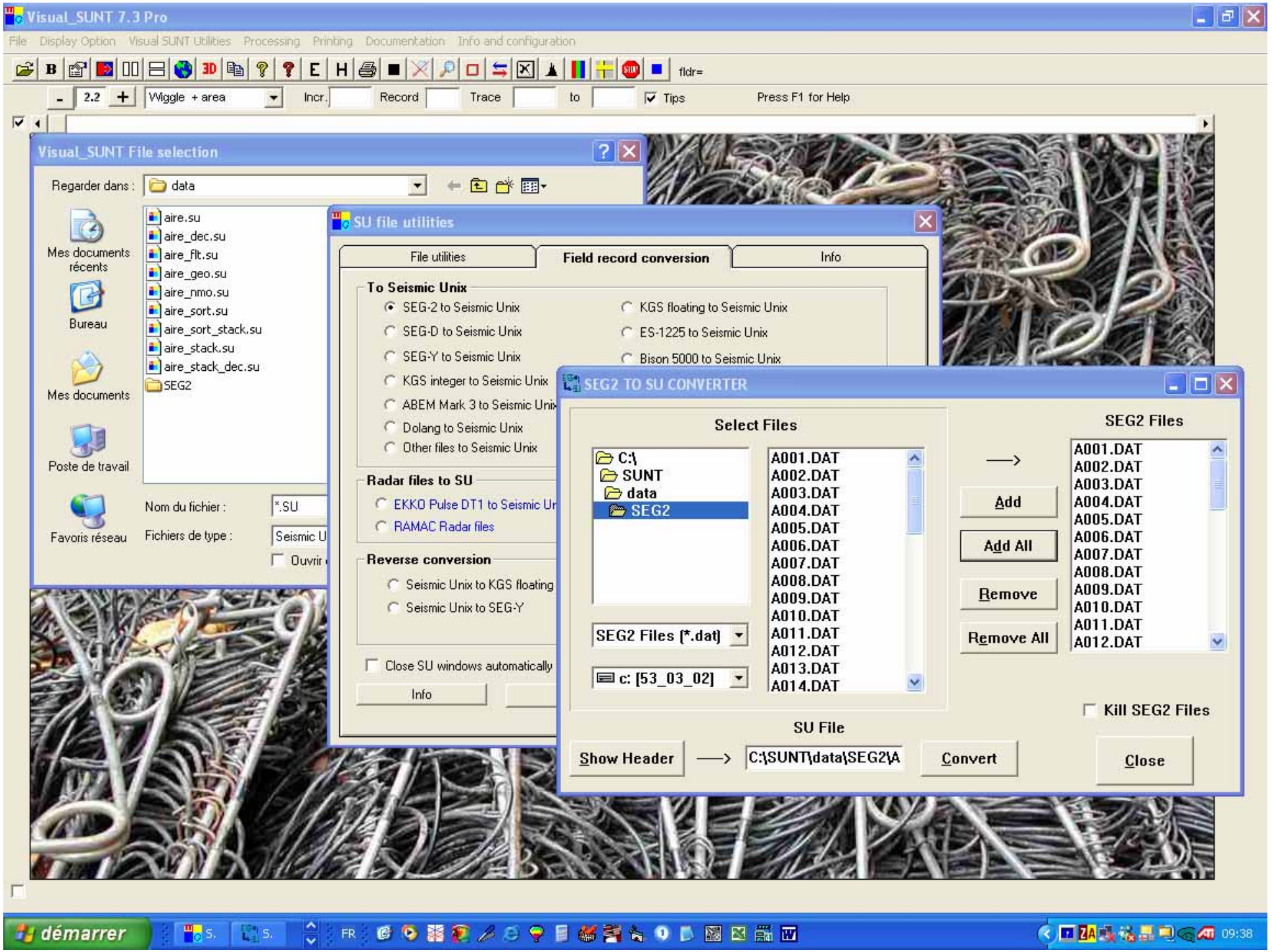
Drop weight


Vibrator

Mini-vibrator

Data processing

Step 1:
SEG2 format to Seismic Unix conversion


Visual_SUNT 7.3 Pro
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr=
2.2
Wiggle + area
Incr.
Record
Trace
to
Tips
Press F1 for Help
Visual_SUNT File selection
Regarder dans :
data
aire.su
aire_dec.su
aire_flt.su
aire_geo.su
aire_nmo.su
aire_sort.su
aire_sort_stack.su
aire_stack.su
aire_stack_dec.su
SEG2
Mes documents récents
Bureau
Mes documents
Poste de travail
Favoris réseau
Nom du fichier :
*.SU
Fichiers de type :
Seismic U
Ouvrir
SU file utilities
File utilities
Field record conversion
Info
To Seismic Unix
SEG-2 to Seismic Unix
SEG-D to Seismic Unix
SEG-Y to Seismic Unix
KGS integer to Seismic Unix
ABEM Mark 3 to Seismic Unix
Dolang to Seismic Unix
Other files to Seismic Unix
KGS floating to Seismic Unix
ES-1225 to Seismic Unix
Bison 5000 to Seismic Unix
Radar files to SU
EKKO Pulse DT1 to Seismic Ur
RAMAC Radar files
Reverse conversion
Seismic Unix to KGS floating
Seismic Unix to SEG-Y
Close SU windows automatically
Info
SEG2 TO SU CONVERTER
Select Files
C:\
SUNT
data
SEG2
SEG2 Files (*.dat)
c: [53_03_02]
A001.DAT
A002.DAT
A003.DAT
A004.DAT
A005.DAT
A006.DAT
A007.DAT
A008.DAT
A009.DAT
A010.DAT
A011.DAT
A012.DAT
A013.DAT
A014.DAT
Add
Add All
Remove
Remove All
SEG2 Files
A001.DAT
A002.DAT
A003.DAT
A004.DAT
A005.DAT
A006.DAT
A007.DAT
A008.DAT
A009.DAT
A010.DAT
A011.DAT
A012.DAT
Kill SEG2 Files
SU File
Show Header
C:\SUNT\data\SEG2\A
Convert
Close
démarrer
FR
09:38

Seismic file structure

SEGY File structure
3200 bytes **EBCDIC** text header
400 bytes **binary** header
240 bytes **trace 1 header**
seismic trace 1 data
240 bytes **trace 2 header**
seismic trace 2 data
..

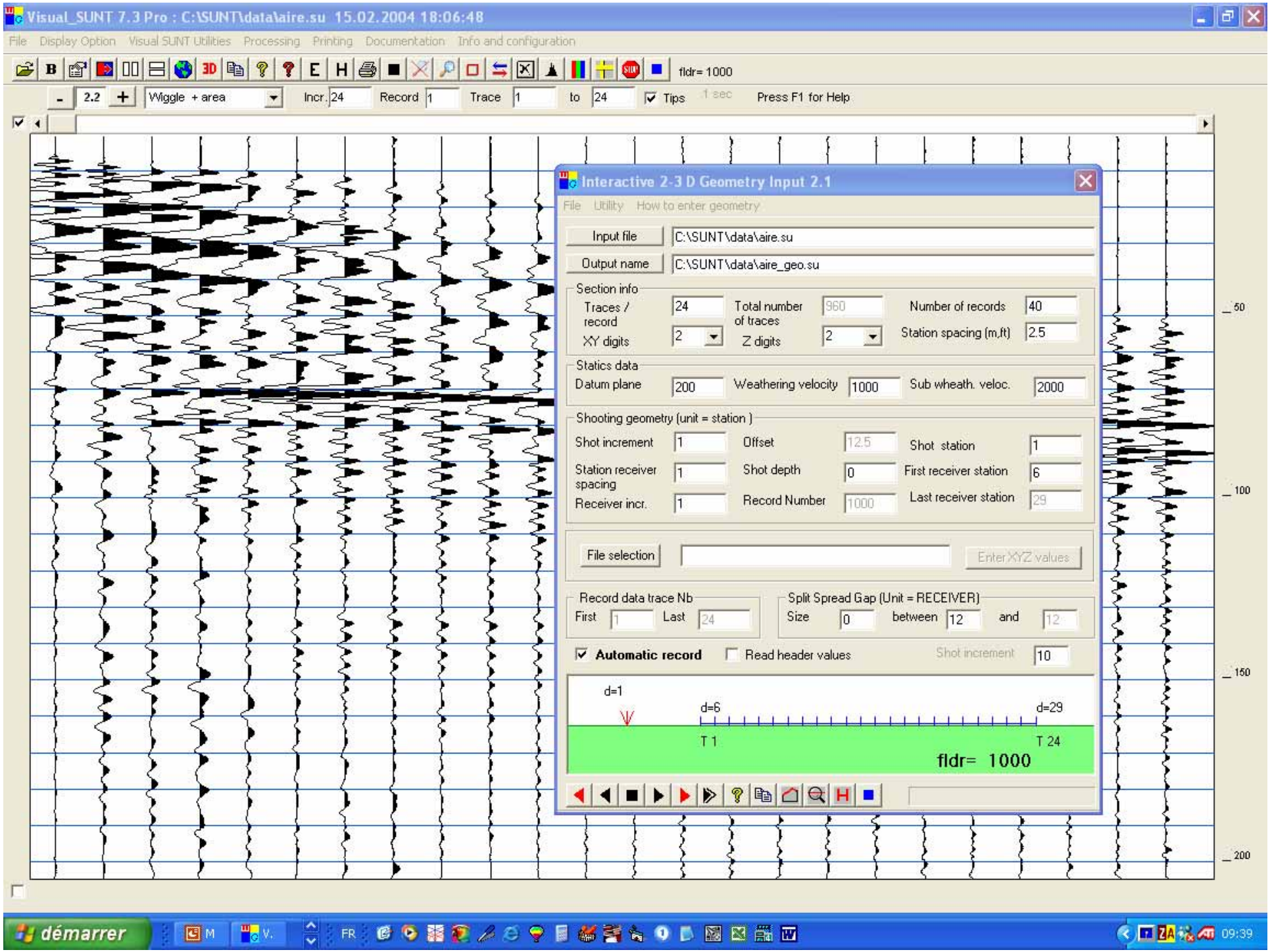
SU File structure
240 bytes **trace 1 header**
seismic trace 1 data
240 bytes **trace 2 header**
seismic trace 2 data
240 bytes **trace 3 header**
seismic trace 3 data

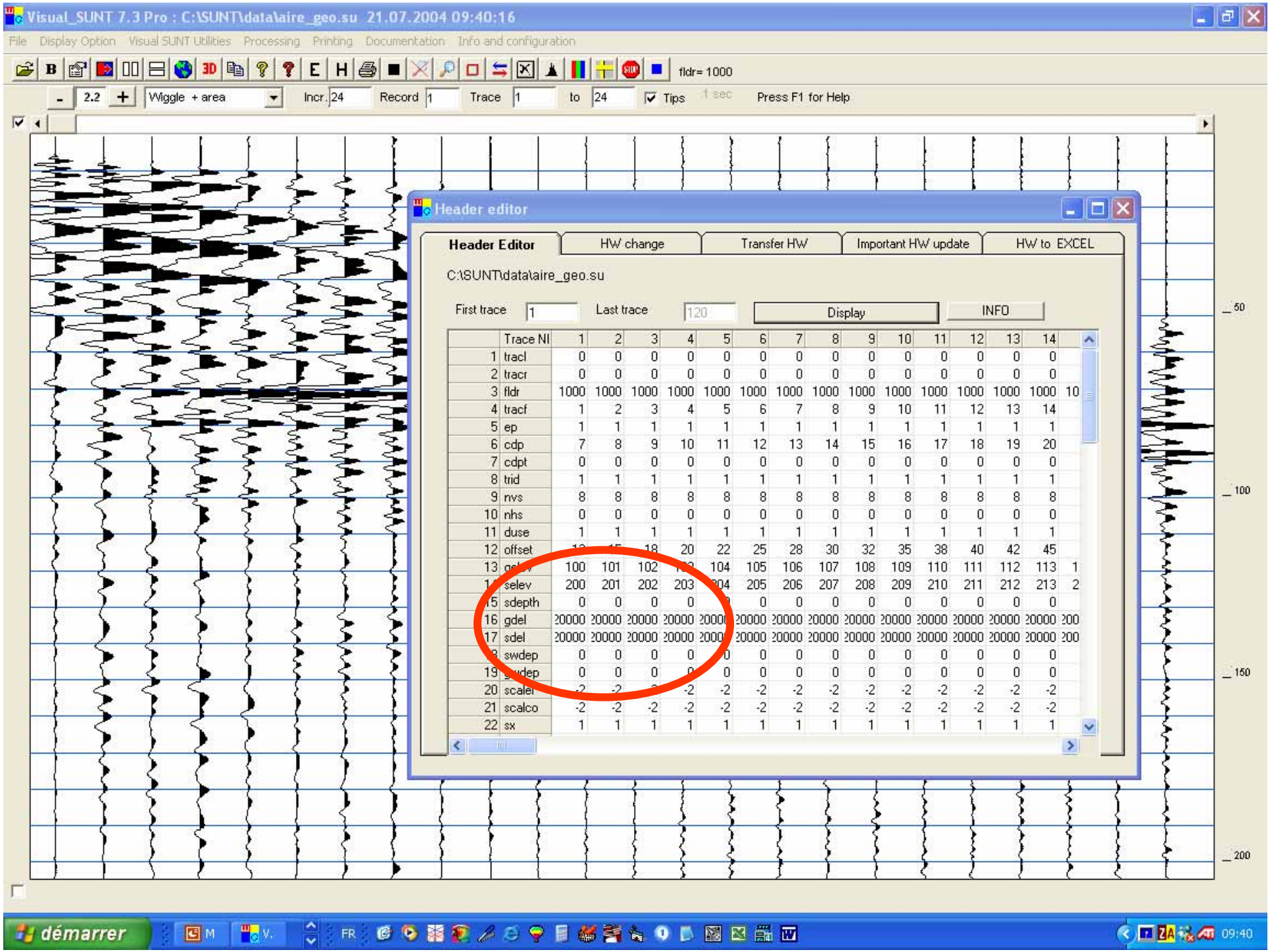
Trace length = trace header 240 bytes + Nb Sample * 4 bytes

SEG-Y

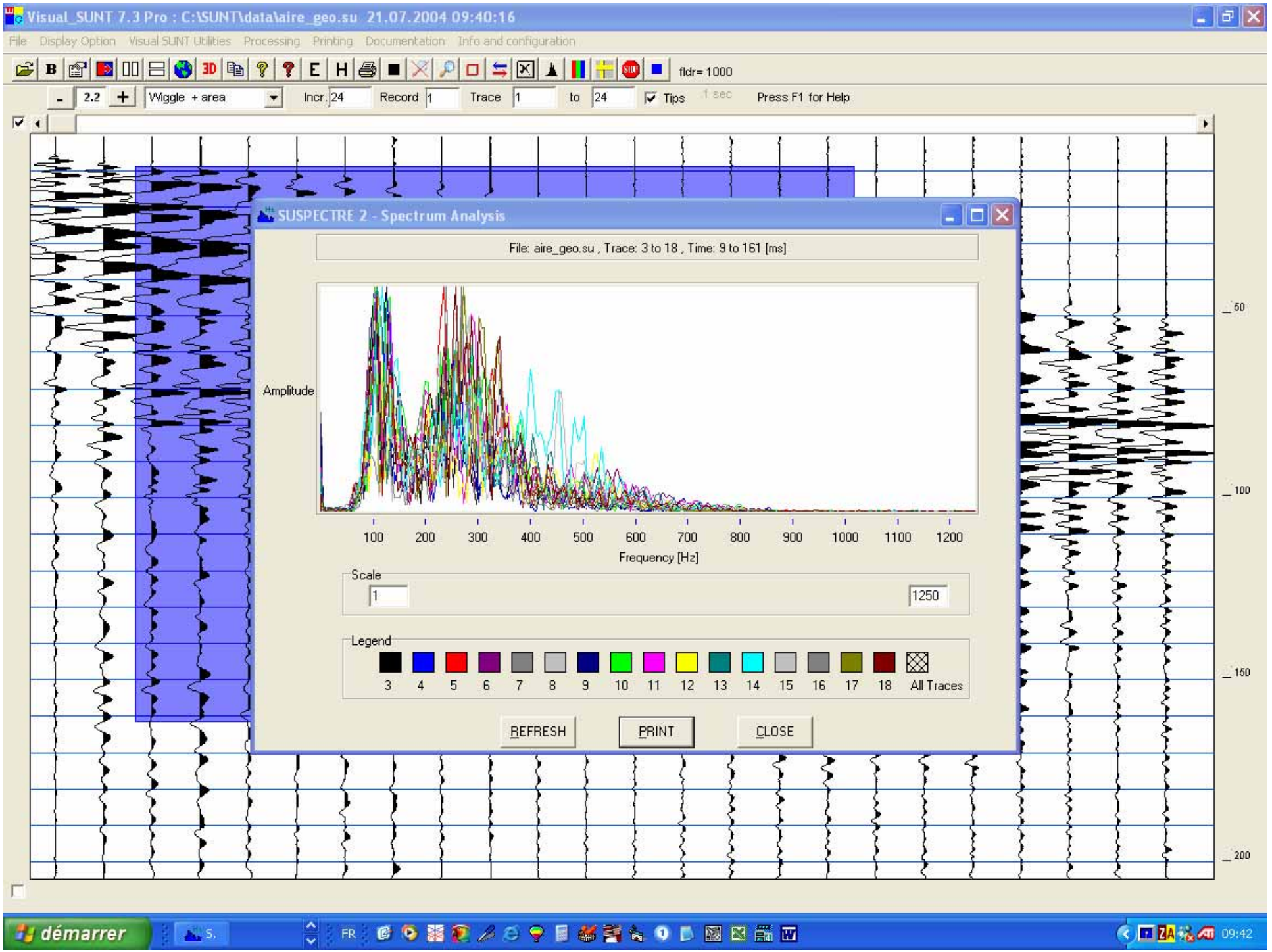
SU

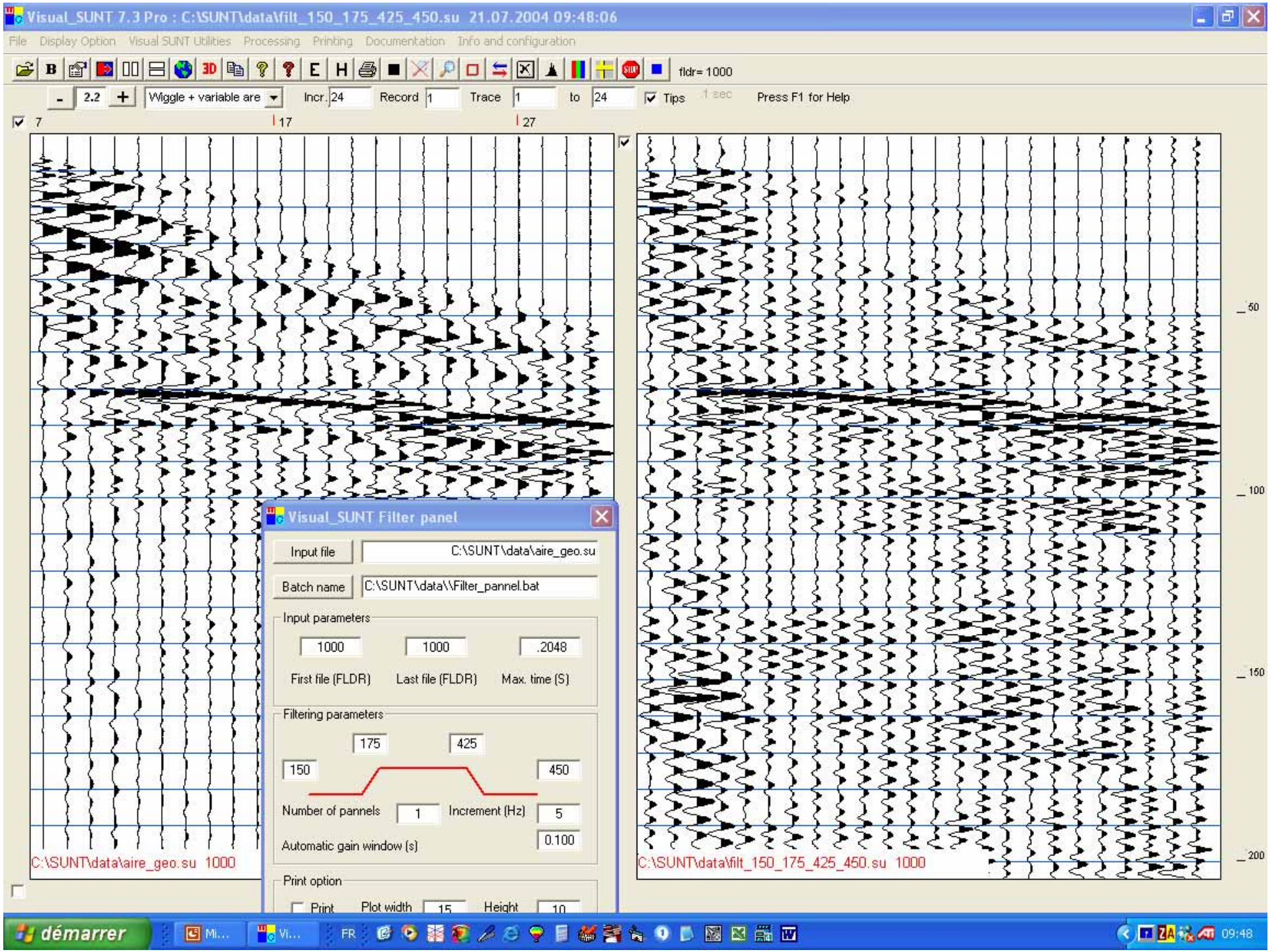
Step 2: Geometry input in trace header


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire.su 15.02.2004 18:06:48
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + area
Incr. 24
Record 1
Trace 1
to 24
Tips
Press F1 for Help
Interactive 2-3 D Geometry Input 2.1
File Utility How to enter geometry
Input file
C:\SUNT\data\aire.su
Output name
C:\SUNT\data\aire_geo.su
Section info
Traces / record 24
Total number of traces 960
Number of records 40
XY digits 2
Z digits 2
Station spacing (m,ft) 2.5
Statics data
Datum plane 200
Weathering velocity 1000
Sub wheath. veloc. 2000
Shooting geometry (unit = station)
Shot increment 1
Offset 12.5
Shot station 1
Station receiver spacing 1
Shot depth 0
First receiver station 6
Receiver incr. 1
Record Number 1000
Last receiver station 29
File selection
Enter XYZ values
Record data trace Nb
First 1
Last 24
Split Spread Gap (Unit = RECEIVER)
Size 0
between 12
and 12
Automatic record
Read header values
Shot increment 10
d=1
d=6
d=29
T 1
T 24
fldr= 1000
50
100
150
200
démarrer
09:39


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_geo.su 21.07.2004 09:40:16
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
2.2
Wiggle + area
Incr. 24
Record 1
Trace 1
to 24
Tips
1 sec
Press F1 for Help
Header editor
Header Editor
HW change
Transfer HW
Important HW update
HW to EXCEL
C:\SUNT\data\aire_geo.su
First trace 1
Last trace 120
Display
INFO
Trace Nl 1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 tracl 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2 tracr 0 0 0 0 0 0 0 0 0 0 0 0 0 0
3 fldr 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000
4 tracf 1 2 3 4 5 6 7 8 9 10 11 12 13 14
5 ep 1 1 1 1 1 1 1 1 1 1 1 1 1 1
6 cdp 7 8 9 10 11 12 13 14 15 16 17 18 19 20
7 cdpt 0 0 0 0 0 0 0 0 0 0 0 0 0 0
8 trid 1 1 1 1 1 1 1 1 1 1 1 1 1 1
9 nvs 8 8 8 8 8 8 8 8 8 8 8 8 8 8
10 nhs 0 0 0 0 0 0 0 0 0 0 0 0 0 0
11 duse 1 1 1 1 1 1 1 1 1 1 1 1 1 1
12 offset 18 20 22 25 28 30 32 35 38 40 42 45
13 100 101 102 104 105 106 107 108 109 110 111 112 113
selev 200 201 202 203 205 206 207 208 209 210 211 212 213
sdepth 0 0 0 0 0 0 0 0 0 0 0 0 0
gdel 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000
sdel 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000 20000
swdep 0 0 0 0 0 0 0 0 0 0 0 0 0 0
gwdep 0 0 0 0 0 0 0 0 0 0 0 0 0 0
scalel -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2
scalco -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2
sx 1 1 1 1 1 1 1 1 1 1 1 1 1 1
50
100
150
200
démarrer
09:40

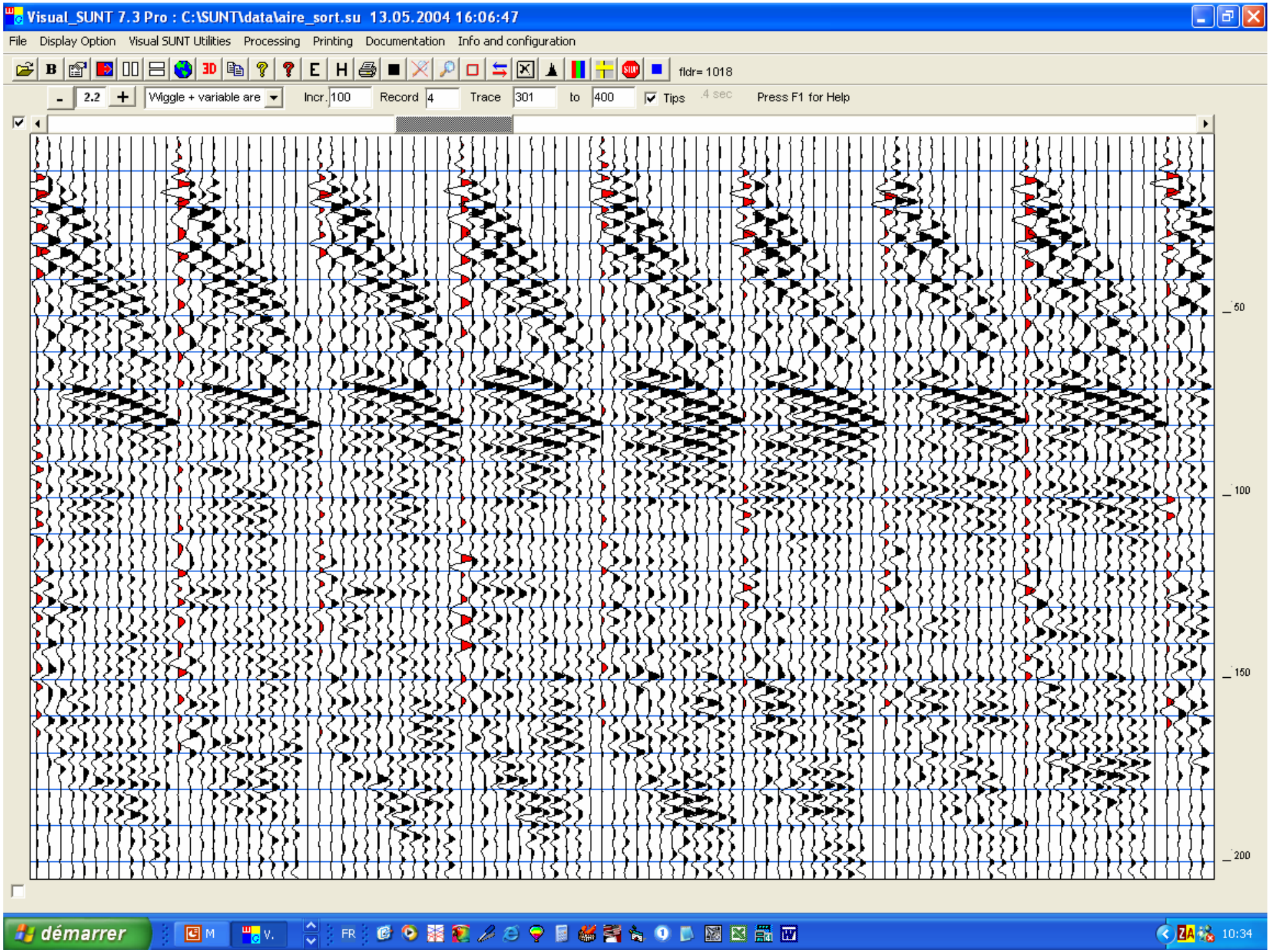
Step 3: Frequency spectrum and filtering


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_geo.su 21.07.2004 09:40:16
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
2.2
Wiggle + area
Incr. 24
Record 1
Trace 1
to 24
Tips
1 sec
Press F1 for Help
SUSPECTRE 2 - Spectrum Analysis
File: aire_geo.su , Trace: 3 to 18 , Time: 9 to 161 [ms]
Amplitude
100 200 300 400 500 600 700 800 900 1000 1100 1200
Frequency [Hz]
Scale
1
1250
Legend
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 All Traces
REFRESH
PRINT
CLOSE
50
100
150
200
démarrer
FR
09:42


Visual_SUNT 7.3 Pro : C:\SUNT\data\filt_150_175_425_450.su 21.07.2004 09:48:06
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + variable are
Incr. 24
Record 1
Trace 1
to 24
Tips
Press F1 for Help
7
17
27
50
100
150
200
C:\SUNT\data\aire_geo.su 1000
C:\SUNT\data\filt_150_175_425_450.su 1000
Visual_SUNT Filter panel
Input file
C:\SUNT\data\aire_geo.su
Batch name
C:\SUNT\data\\Filter_pannel.bat
Input parameters
1000
1000
.2048
First file (FLDR)
Last file (FLDR)
Max. time (S)
Filtering parameters
175
425
150
450
Number of pannels
1
Increment (Hz)
5
Automatic gain window (s)
0.100
Print option
Print
Plot width
15
Height
10
démarrer
09:48

SORT

Traces must be sorted by CDP
instead Shot to continue the processing


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_sort.su 13.05.2004 16:06:47
File
Display Option
Visual SUNT Utilities
Processing
Printing
Documentation
Info and configuration
fldr= 1018
2.2
Wiggle + variable are
Incr. 100
Record 4
Trace 301
to 400
Tips
.4 sec
Press F1 for Help
50
100
150
200
démarrer
FR
10:34

Step 4: Velocity scan

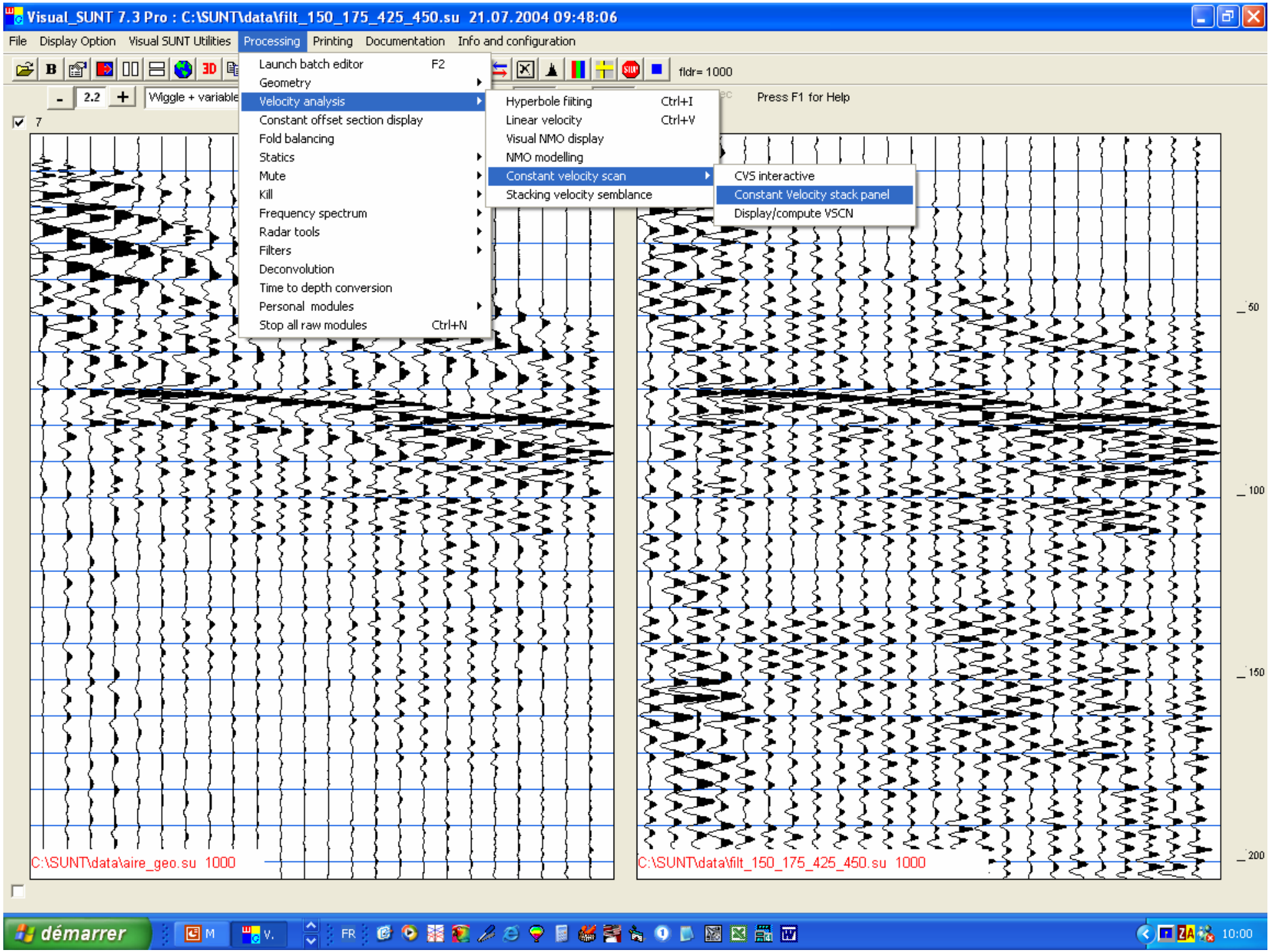
You must select a SORTED file

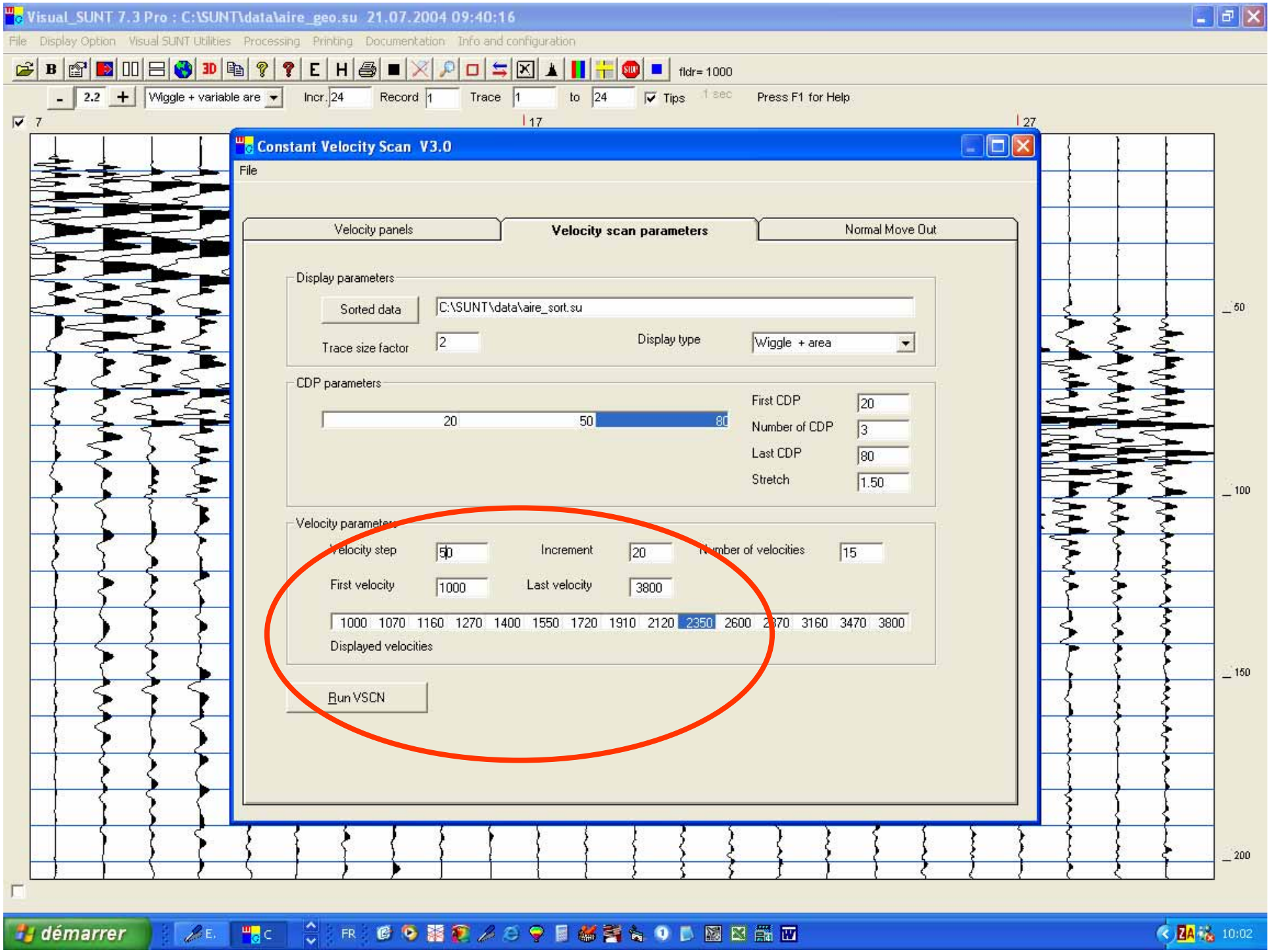
There are any many tools to determine NMO velocities:

-Constant velocity scan

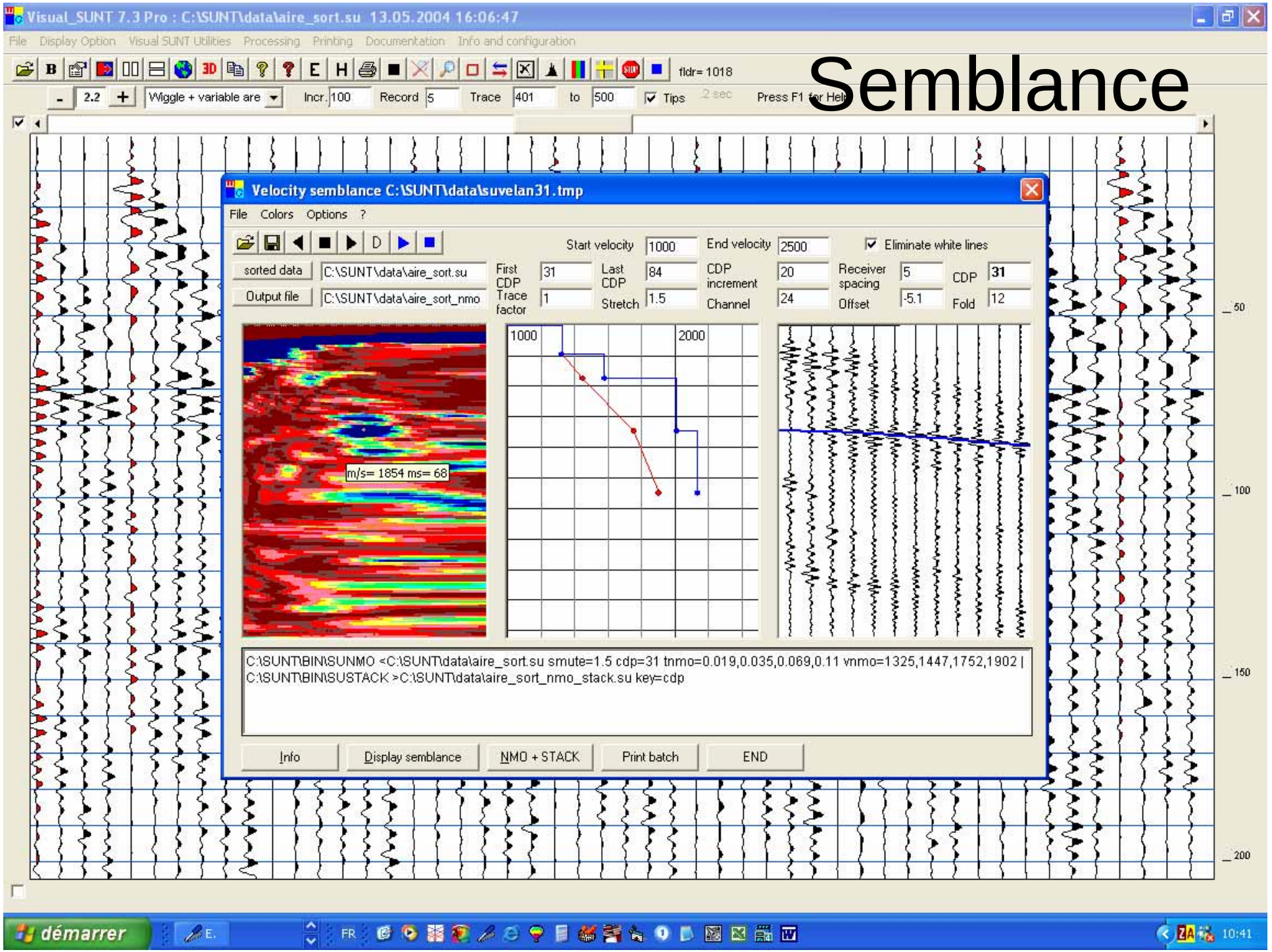
-Semblance

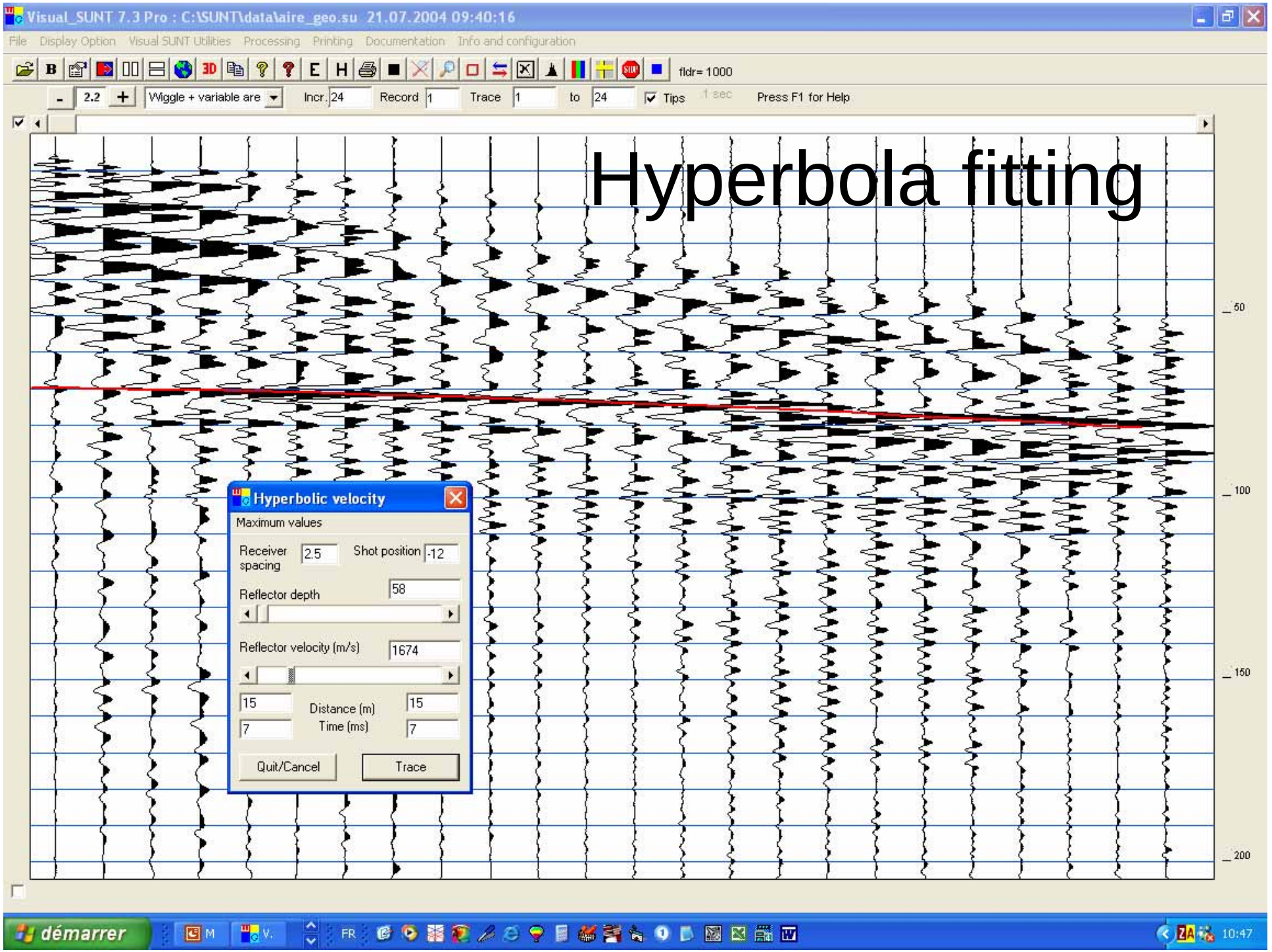
-Hyperbola fitting


Visual_SUNT 7.3 Pro : C:\SUNT\data\filt_150_175_425_450.su 21.07.2004 09:48:06
File
Display Option
Visual SUNT Utilities
Processing
Printing
Documentation
Info and configuration
Launch batch editor F2
Geometry
Velocity analysis
Constant offset section display
Fold balancing
Statics
Mute
Kill
Frequency spectrum
Radar tools
Filters
Deconvolution
Time to depth conversion
Personal modules
Stop all raw modules Ctrl+N
Hyperbole fiiting Ctrl+I
Linear velocity Ctrl+V
Visual NMO display
NMO modelling
Constant velocity scan
Stacking velocity semblance
CVS interactive
Constant Velocity stack panel
Display/compute VSCN
fldr= 1000
Press F1 for Help
Wiggle + variable
2.2
C:\SUNT\data\aire_geo.su 1000
C:\SUNT\data\filt_150_175_425_450.su 1000
50
100
150
200
démarrer
10:00


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_geo.su 21.07.2004 09:40:16
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + variable are
Incr. 24
Record 1
Trace 1
to 24
Tips
Press F1 for Help
Constant Velocity Scan V3.0
File
Velocity panels
Velocity scan parameters
Normal Move Out
Display parameters
Sorted data
C:\SUNT\data\aire_sort.su
Trace size factor
2
Display type
Wiggle + area
CDP parameters
20
50
80
First CDP
20
Number of CDP
3
Last CDP
80
Stretch
1.50
Velocity parameters
Velocity step
50
Increment
20
Number of velocities
15
First velocity
1000
Last velocity
3800
1000 1070 1160 1270 1400 1550 1720 1910 2120 2350 2600 2870 3160 3470 3800
Displayed velocities
Run VSCN
démarrer
10:02

1 column= 1 velocity for the first CDP group


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_sort.su 13.05.2004 16:06:47
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1018
Wiggle + variable are
Incr. 100 Record 5 Trace 401 to 500 Tips
Press F1 for Help
Semblance
Velocity semblance C:\SUNT\data\suvelan31.tmp
File Colors Options ?
Start velocity 1000 End velocity 2500 Eliminate white lines
sorted data C:\SUNT\data\aire_sort.su
Output file C:\SUNT\data\aire_sort_nmo
First CDP 31 Last CDP 84 CDP increment 20 Receiver spacing 5 CDP 31
Trace factor 1 Stretch 1.5 Channel 24 Offset -5.1 Fold 12
m/s= 1854 ms= 68
1000
2000
C:\SUNT\BIN\SUNMO <C:\SUNT\data\aire_sort.su smute=1.5 cdp=31 tnmo=0.019,0.035,0.069,0.11 vnmo=1325,1447,1752,1902 |
C:\SUNT\BIN\SUSTACK >C:\SUNT\data\aire_sort_nmo_stack.su key=cdp
Info
Display semblance
NMO + STACK
Print batch
END
50
100
150
200
démarrer
FR
10:41

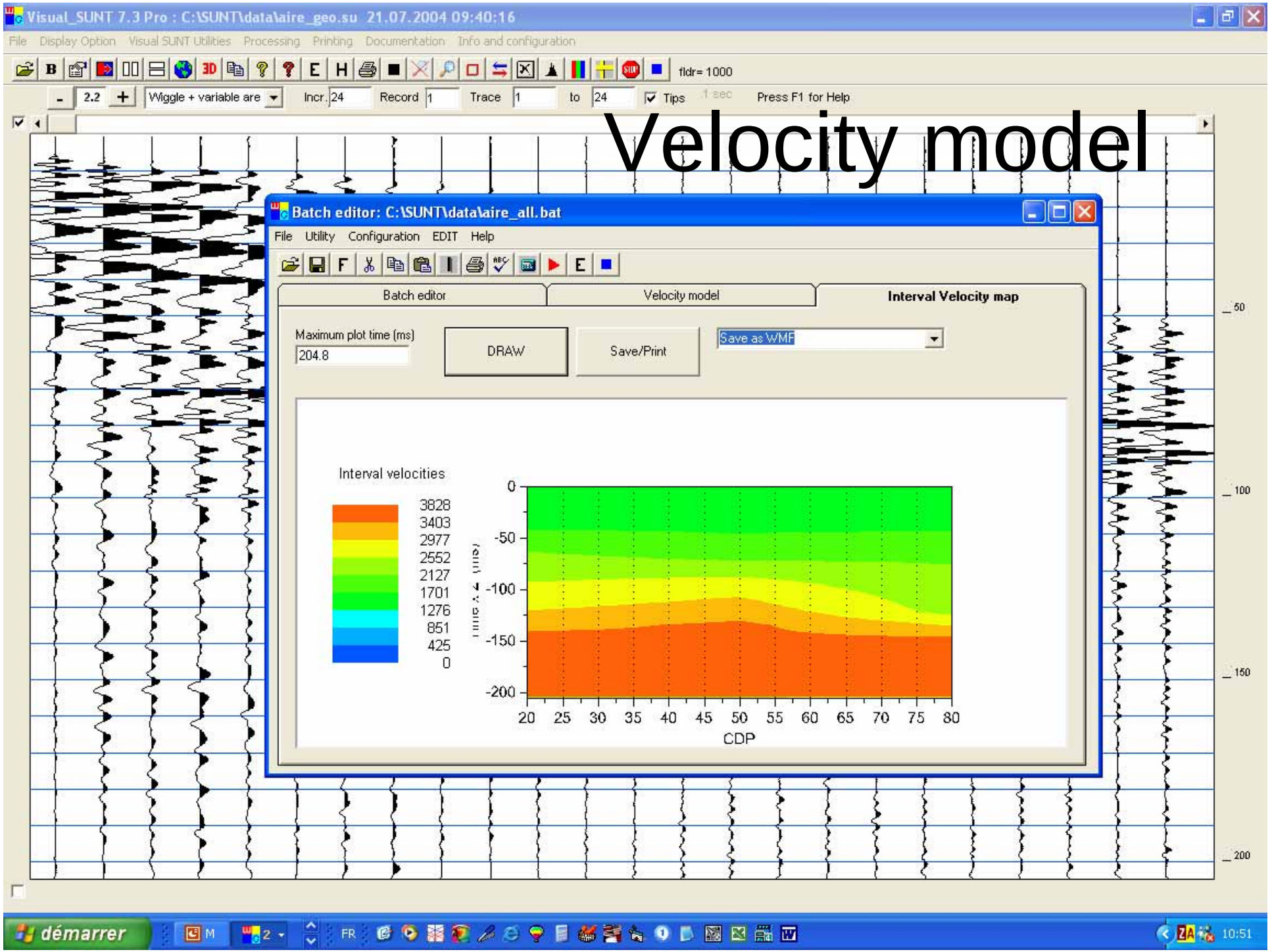

Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_geo.su 21.07.2004 09:40:16
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + variable are
Incr. 24
Record 1
Trace 1
to 24
Tips
Press F1 for Help
Hyperbola fitting
Hyperbolic velocity
Maximum values
Receiver spacing 2.5
Shot position -12
Reflector depth 58
Reflector velocity (m/s) 1674
15
15
Distance (m)
7
7
Time (ms)
Quit/Cancel
Trace
50
100
150
200
démarrer
10:47

Normal Move Out

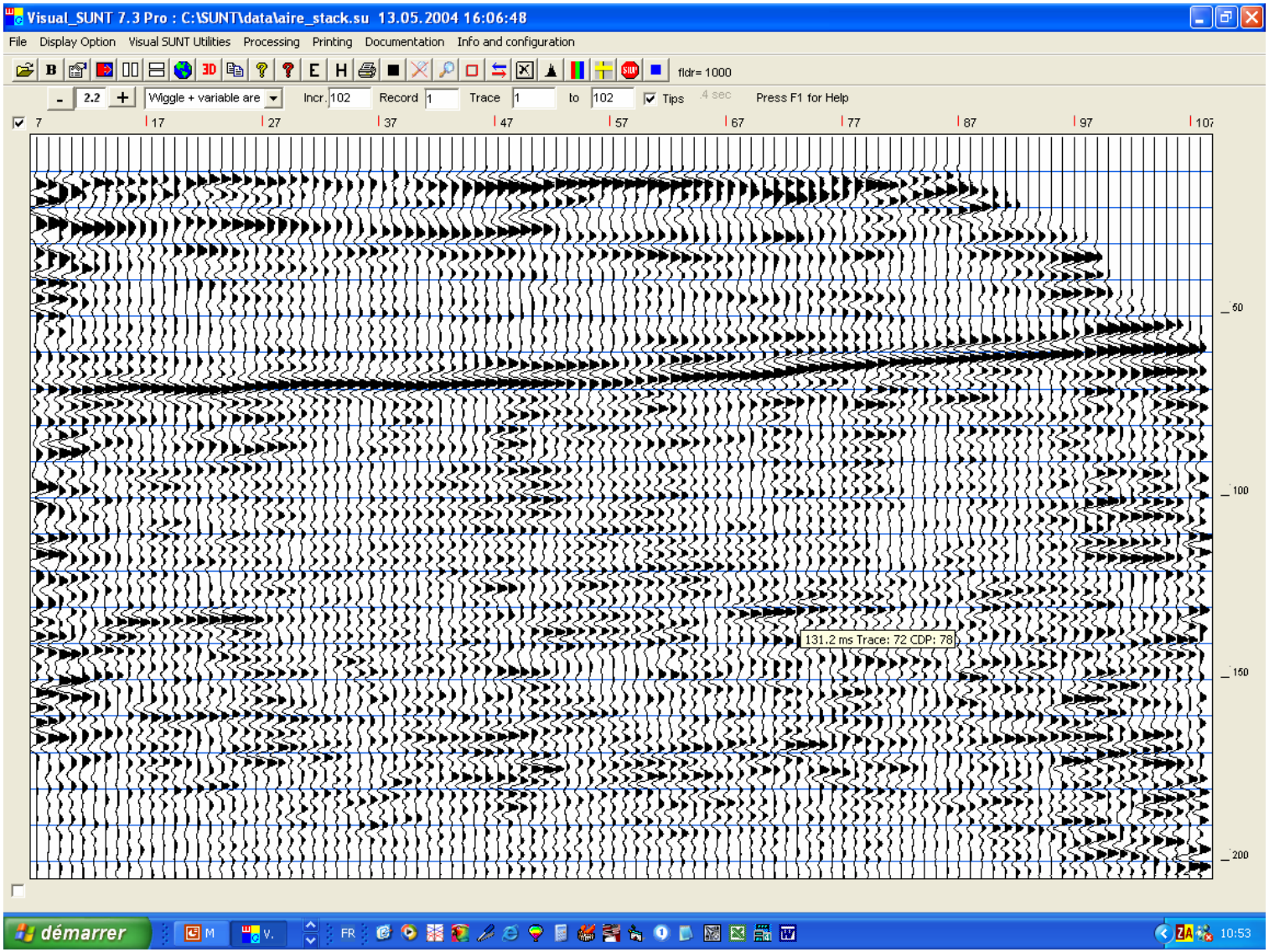
Velocity determination is a great challenge in Reflection seismic processing.

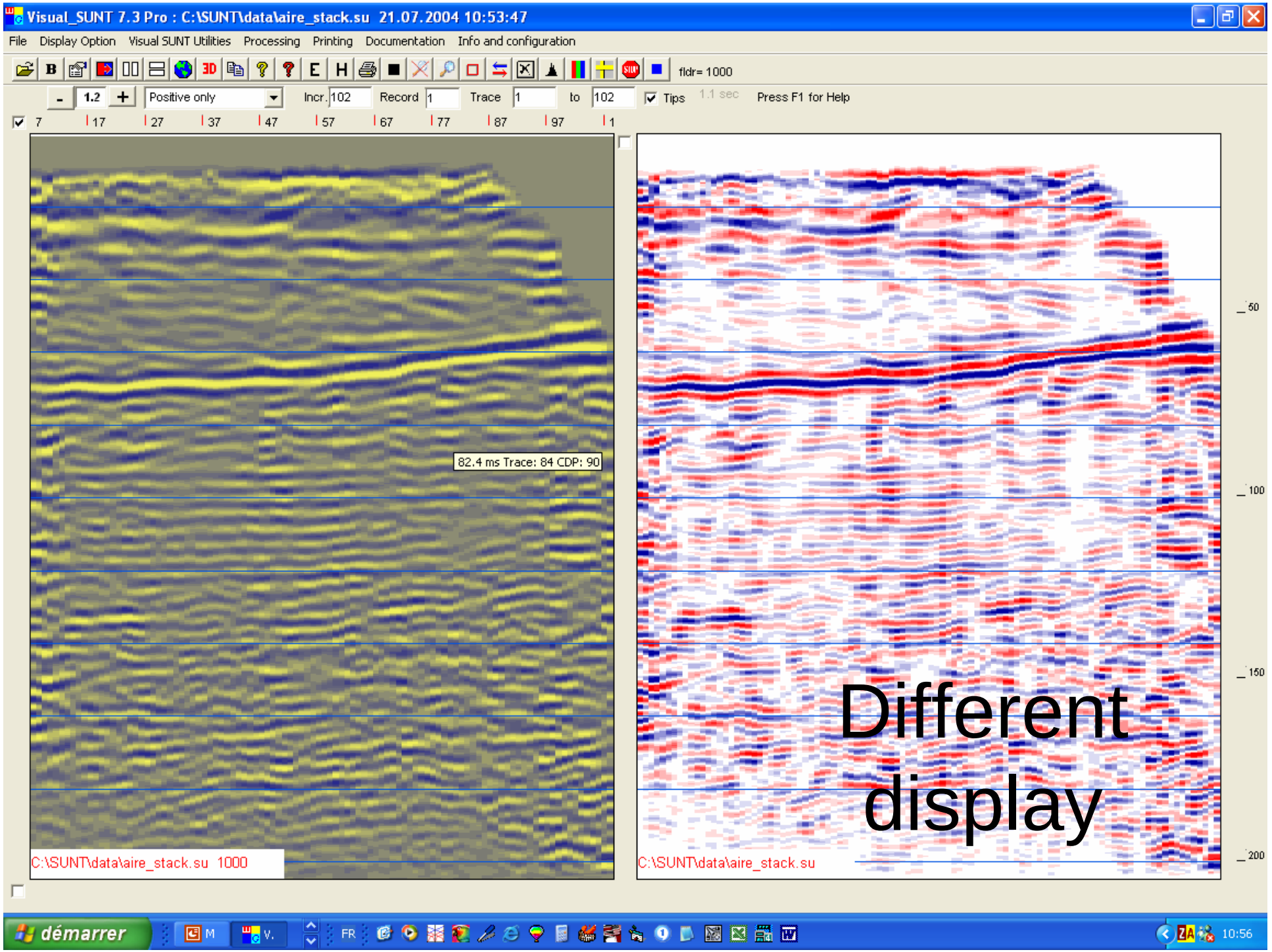
Particularly with high resolution shallow seismic

Now we can STACK (add) traces with the same CDP


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_geo.su 21.07.2004 09:40:16
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + variable are
Incr. 24
Record 1
Trace 1
to 24
Tips
Press F1 for Help
Velocity model
Batch editor: C:\SUNT\data\aire_all.bat
File Utility Configuration EDIT Help
Batch editor
Velocity model
Interval Velocity map
Maximum plot time (ms)
204.8
DRAW
Save/Print
Save as WMF
Interval velocities
3828
3403
2977
2552
2127
1701
1276
851
425
0
0
-50
-100
-150
-200
20 25 30 35 40 45 50 55 60 65 70 75 80
CDP
50
100
150
200
démarrer
FR
10:51

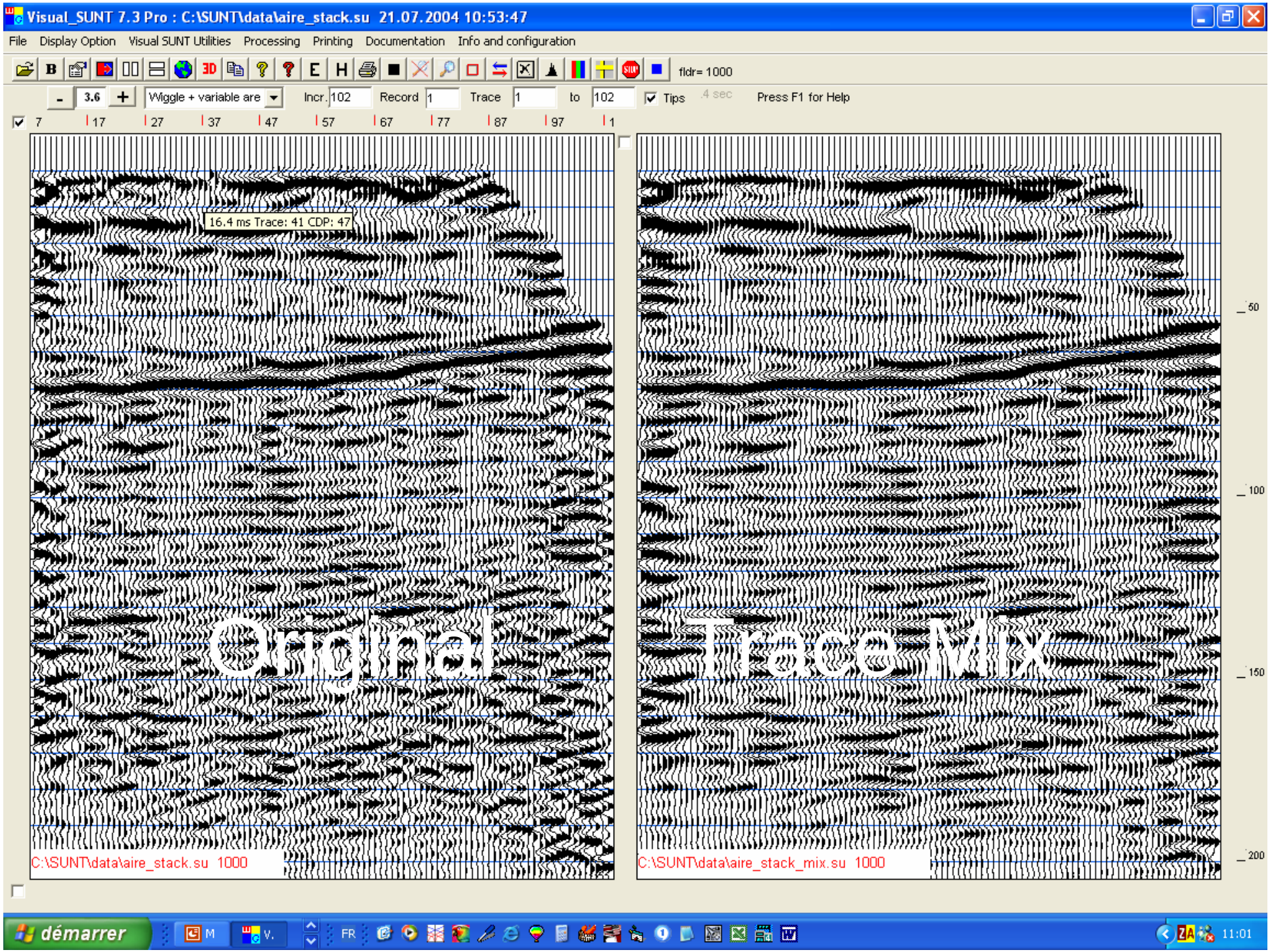
Now we can see the STACKED section!




Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_stack.su 21.07.2004 10:53:47
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Positive only
Incr. 102
Record 1
Trace 1
to 102
Tips
1.1 sec
Press F1 for Help
7 17 27 37 47 57 67 77 87 97 1
82.4 ms Trace: 84 CDP: 90
C:\SUNT\data\aire_stack.su 1000
C:\SUNT\data\aire_stack.su
50
100
150
200
Different display
démarrer
10:56

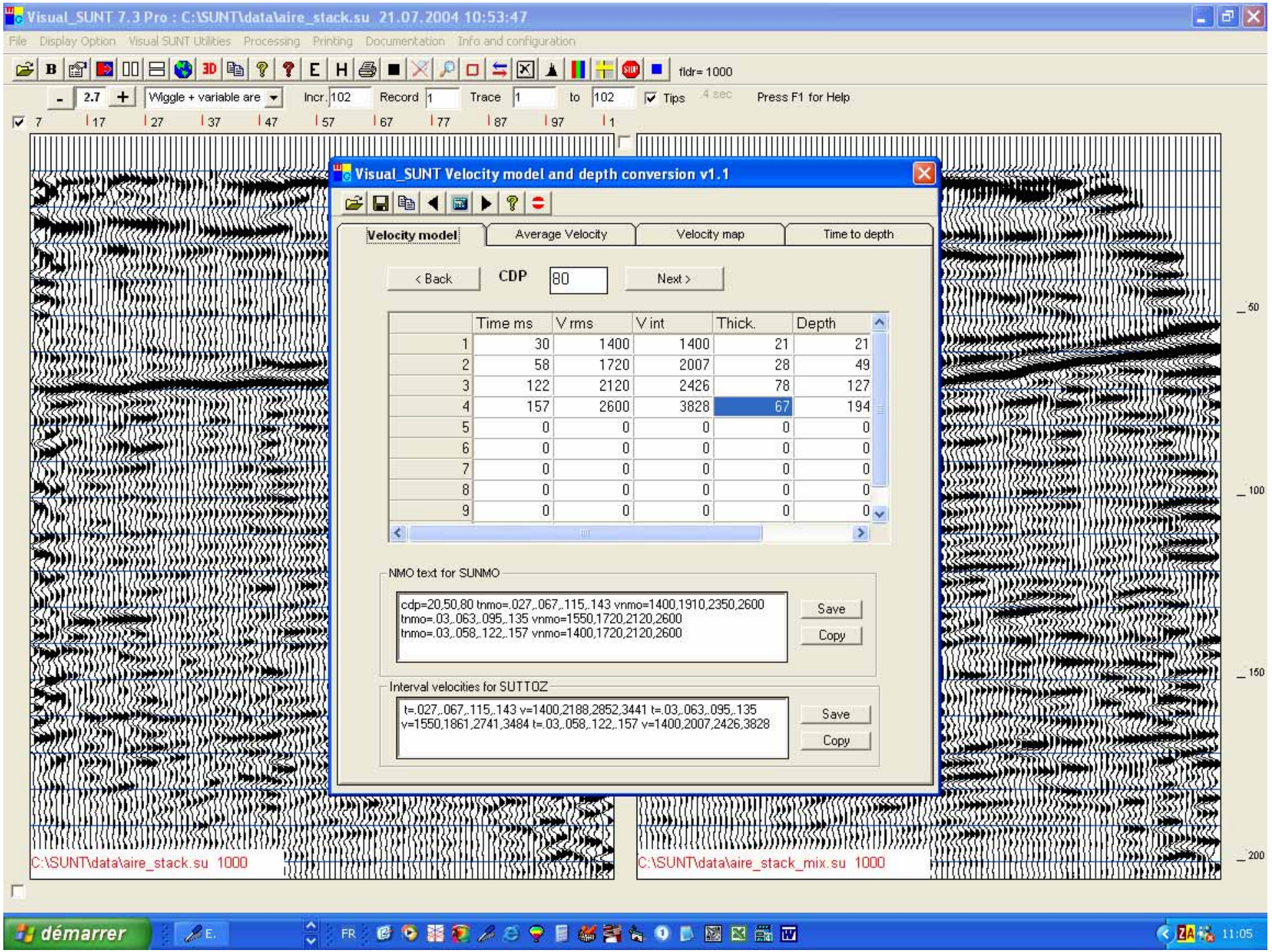
Post stack processing

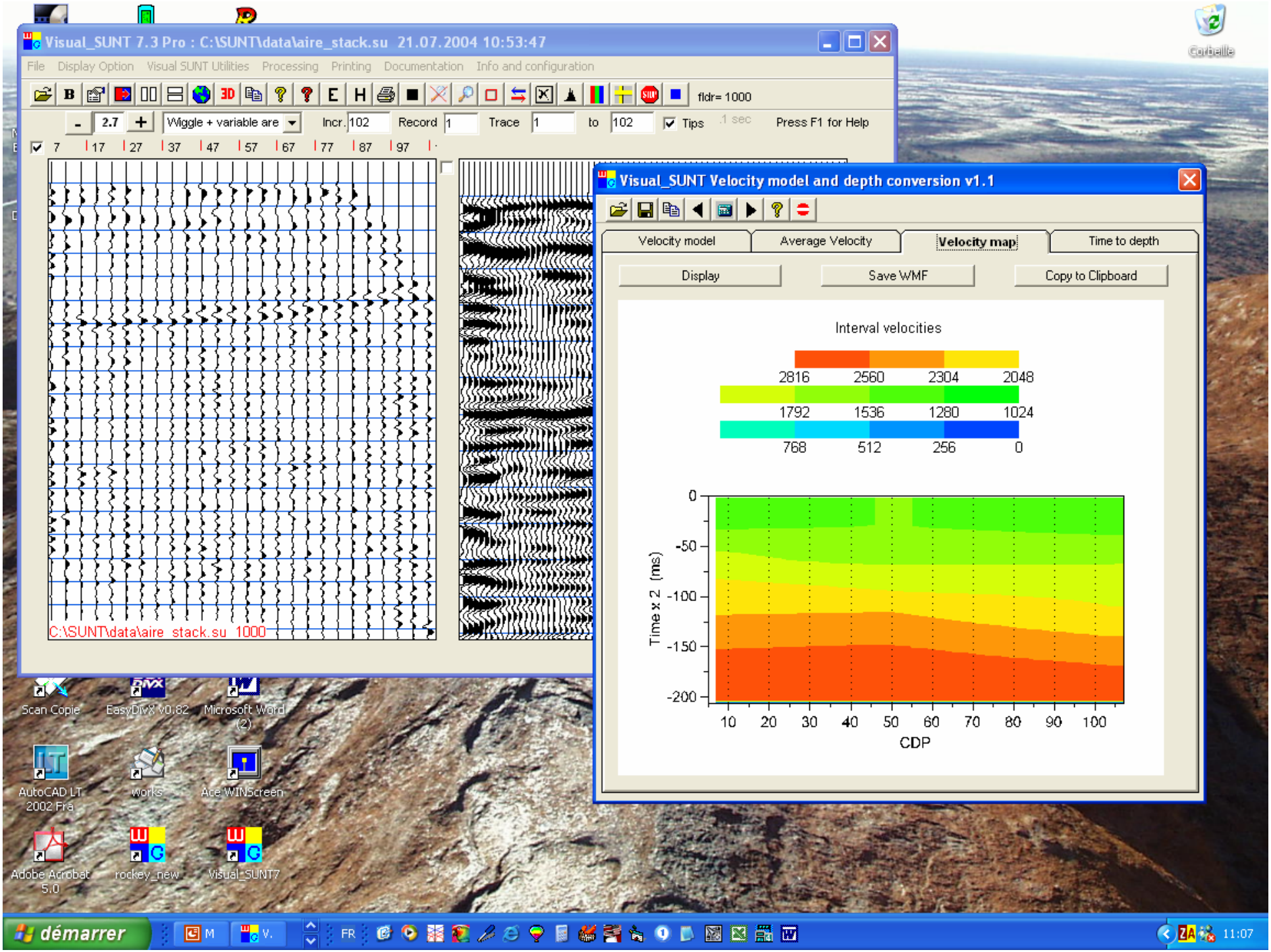
Filtering
Deconvolution
Migration
Trace mix
Residual statics

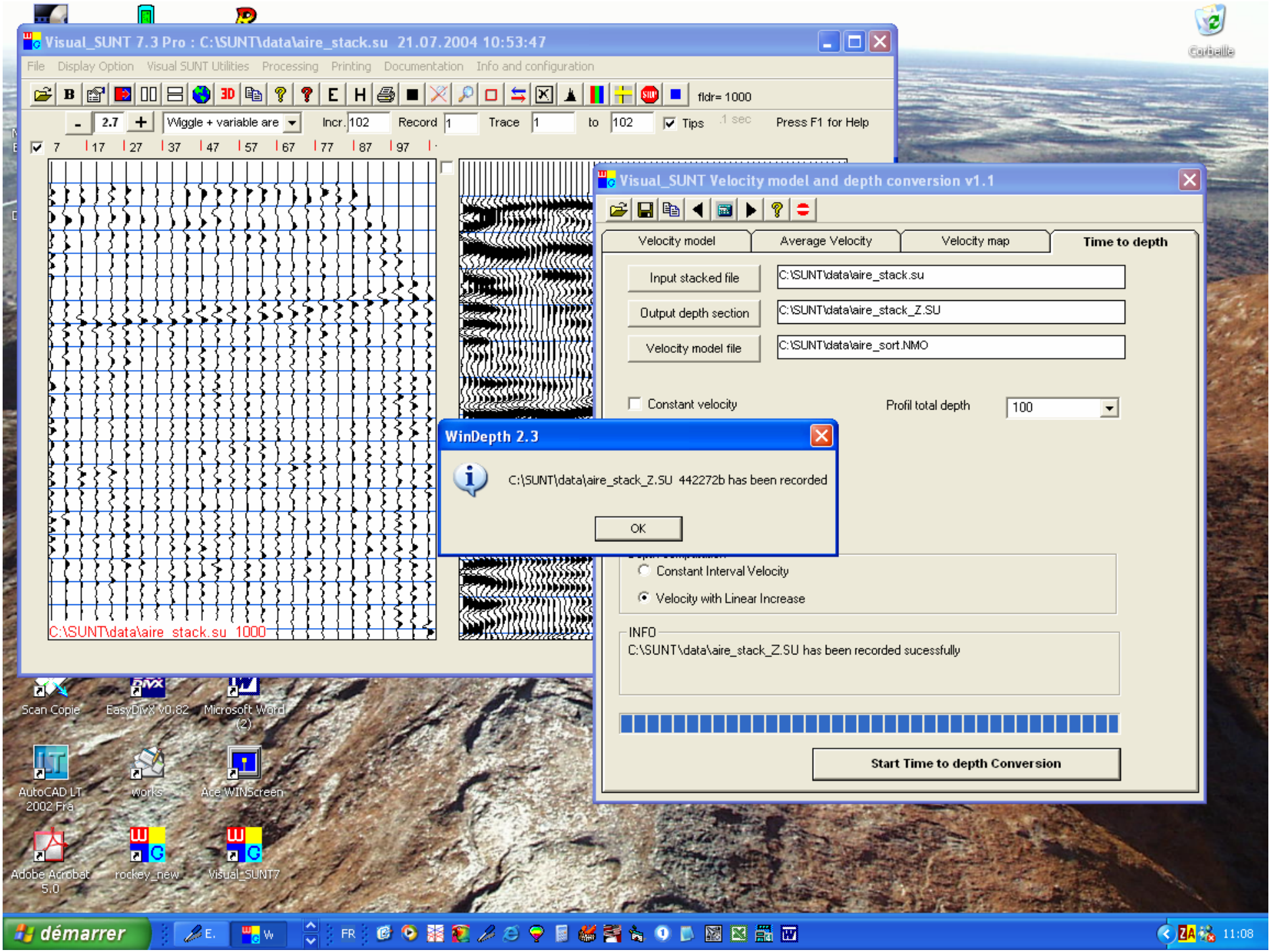

Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_stack.su 21.07.2004 10:53:47
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + variable are
Incr. 102
Record 1
Trace 1
to 102
Tips
Press F1 for Help
16.4 ms Trace: 41 CDP: 47
Original
TraceMix
C:\SUNT\data\aire_stack.su 1000
C:\SUNT\data\aire_stack_mix.su 1000
démarrer
11:01

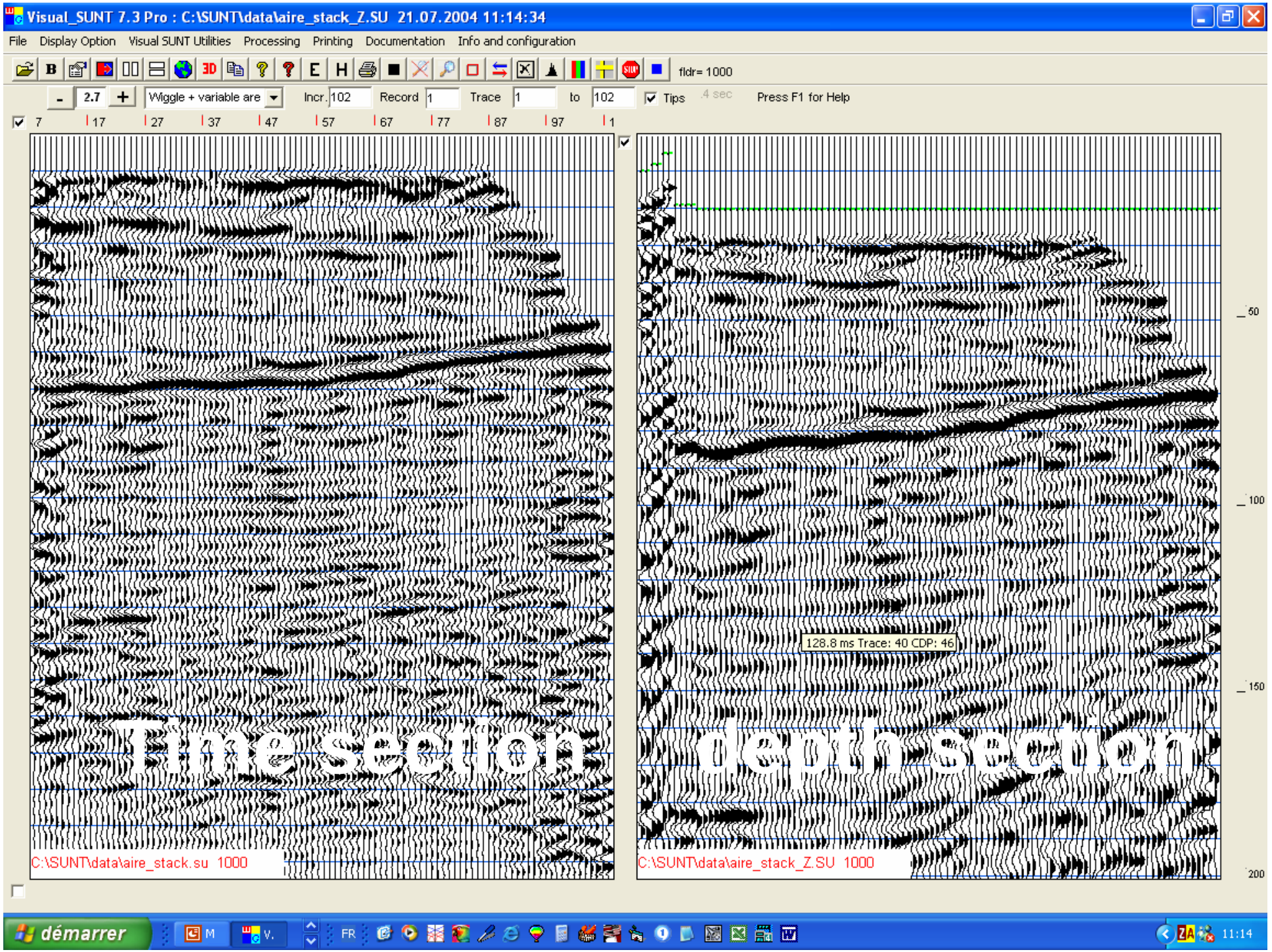
Time to depth conversion

requires a velocity model to convert time to depth


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_stack.su 21.07.2004 10:53:47
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + variable are
Incr. 102
Record 1
Trace 1
to 102
Tips
Press F1 for Help
Visual_SUNT Velocity model and depth conversion v1.1
Velocity model
Average Velocity
Velocity map
Time to depth
< Back
CDP 80
Next >
Time ms V rms V int Thick. Depth
1 30 1400 1400 21 21
2 58 1720 2007 28 49
3 122 2120 2426 78 127
4 157 2600 3828 67 194
5 0 0 0 0 0
6 0 0 0 0 0
7 0 0 0 0 0
8 0 0 0 0 0
9 0 0 0 0 0
NMO text for SUNMO
cdp=20,50,80 tnmo=.027,.067,.115,.143 vnmo=1400,1910,2350,2600
tnmo=.03,.063,.095,.135 vnmo=1550,1720,2120,2600
tnmo=.03,.058,.122,.157 vnmo=1400,1720,2120,2600
Save
Copy
Interval velocities for SUTTOZ
t=.027,.067,.115,.143 v=1400,2188,2852,3441 t=.03,.063,.095,.135
v=1550,1861,2741,3484 t=.03,.058,.122,.157 v=1400,2007,2426,3828
Save
Copy
C:\SUNT\data\aire_stack.su 1000
C:\SUNT\data\aire_stack_mix.su 1000
50
100
150
200
démarrer
FR
11:05


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_stack.su 21.07.2004 10:53:47
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + variable are
Incr. 102
Record 1
Trace 1
to 102
Tips
Press F1 for Help
C:\SUNT\data\aire_stack.su 1000
Visual_SUNT Velocity model and depth conversion v1.1
Velocity model
Average Velocity
Velocity map
Time to depth
Display
Save WMF
Copy to Clipboard
Interval velocities
2816 2560 2304 2048
1792 1536 1280 1024
768 512 256 0
Time x 2 (ms)
0 -50 -100 -150 -200
10 20 30 40 50 60 70 80 90 100
CDP
Corbeille
Scan Copie
EasyDivX V0.82
Microsoft Word (2)
AutoCAD LT 2002 Fra
works
Ace WINScreen
Adobe Acrobat 5.0
rockey_new
Visual_SUNT7
démarrer
FR
11:07

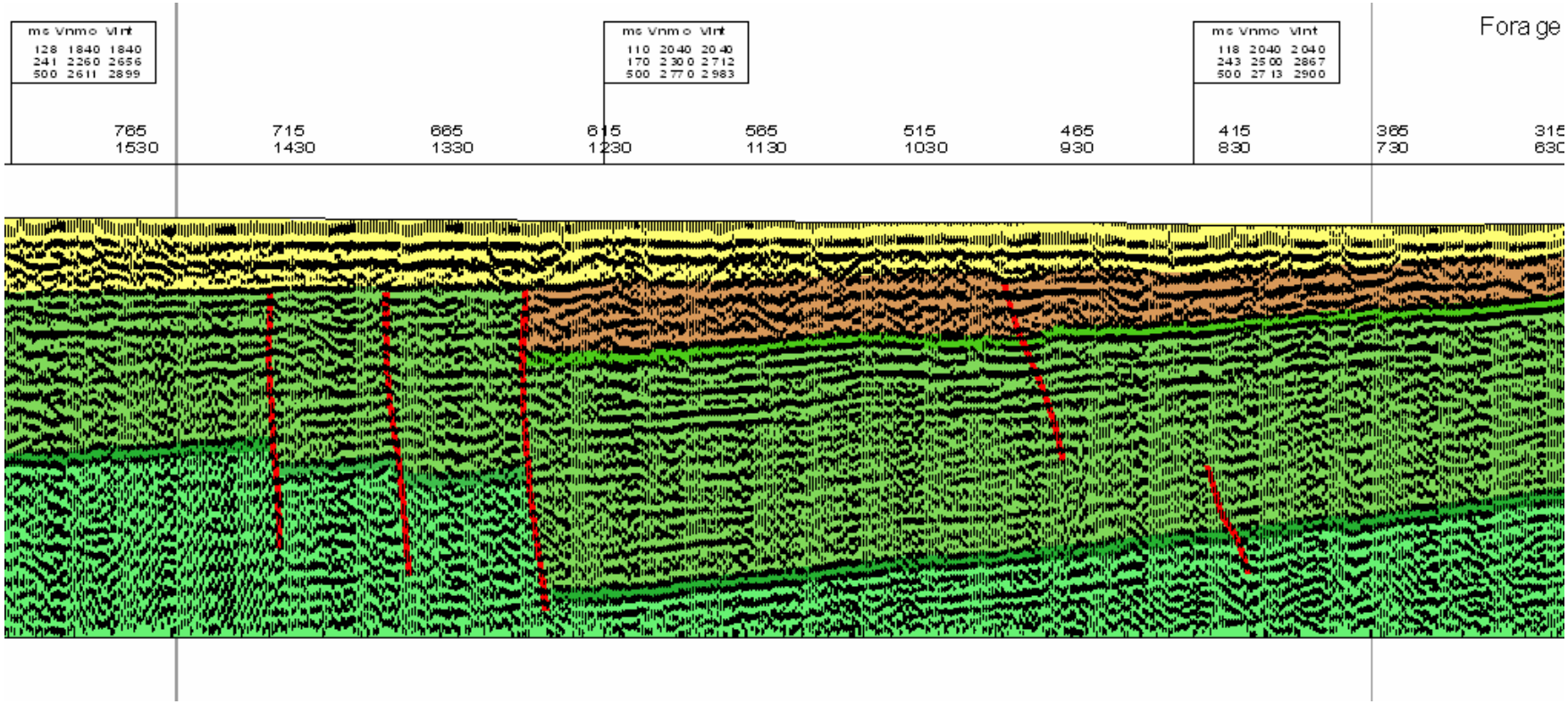

Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_stack.su 21.07.2004 10:53:47
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
Wiggle + variable are
Incr. 102 Record 1 Trace 1 to 102 Tips .1 sec Press F1 for Help
C:\SUNT\data\aire_stack.su 1000
Visual_SUNT Velocity model and depth conversion v1.1
Velocity model
Average Velocity
Velocity map
Time to depth
Input stacked file
C:\SUNT\data\aire_stack.su
Output depth section
C:\SUNT\data\aire_stack_Z.SU
Velocity model file
C:\SUNT\data\aire_sort.NMO
Constant velocity
Profil total depth
100
Constant Interval Velocity
Velocity with Linear Increase
INFO
C:\SUNT\data\aire_stack_Z.SU has been recorded sucessfully
Start Time to depth Conversion
WinDepth 2.3
C:\SUNT\data\aire_stack_Z.SU 442272b has been recorded
OK
Corbeille
Scan Copie
EasyDivX V0.82
Microsoft Word (2)
AutoCAD LT 2002 Fra
works
Ace WINScreen
Adobe Acrobat 5.0
rockey_new
Visual_SUNT7
démarrer
FR
11:08


Visual_SUNT 7.3 Pro : C:\SUNT\data\aire_stack_Z.SU 21.07.2004 11:14:34
File Display Option Visual SUNT Utilities Processing Printing Documentation Info and configuration
fldr= 1000
2.7
Wiggle + variable are
Incr. 102
Record 1
Trace 1
to 102
Tips
.4 sec
Press F1 for Help
7 17 27 37 47 57 67 77 87 97 1
50
100
150
200
128.8 ms Trace: 40 CDP: 46
Time section
depth section
C:\SUNT\data\aire_stack.su 1000
C:\SUNT\data\aire_stack_Z.SU 1000
démarrer
FR
11:14

Examples

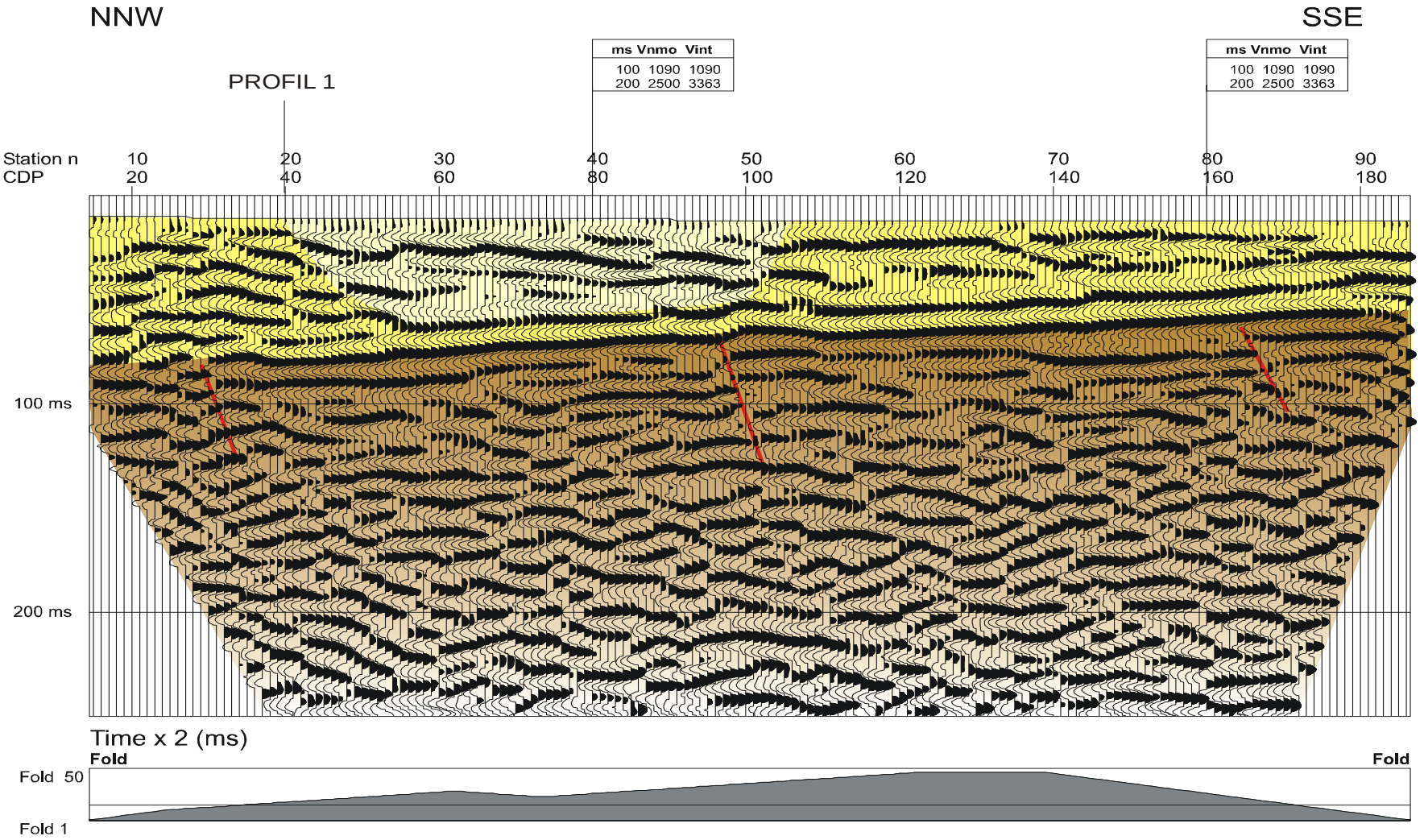

Gabès (Tunisia)

Shot and trace spacing 5m, Energy Vibrator, 48 channels

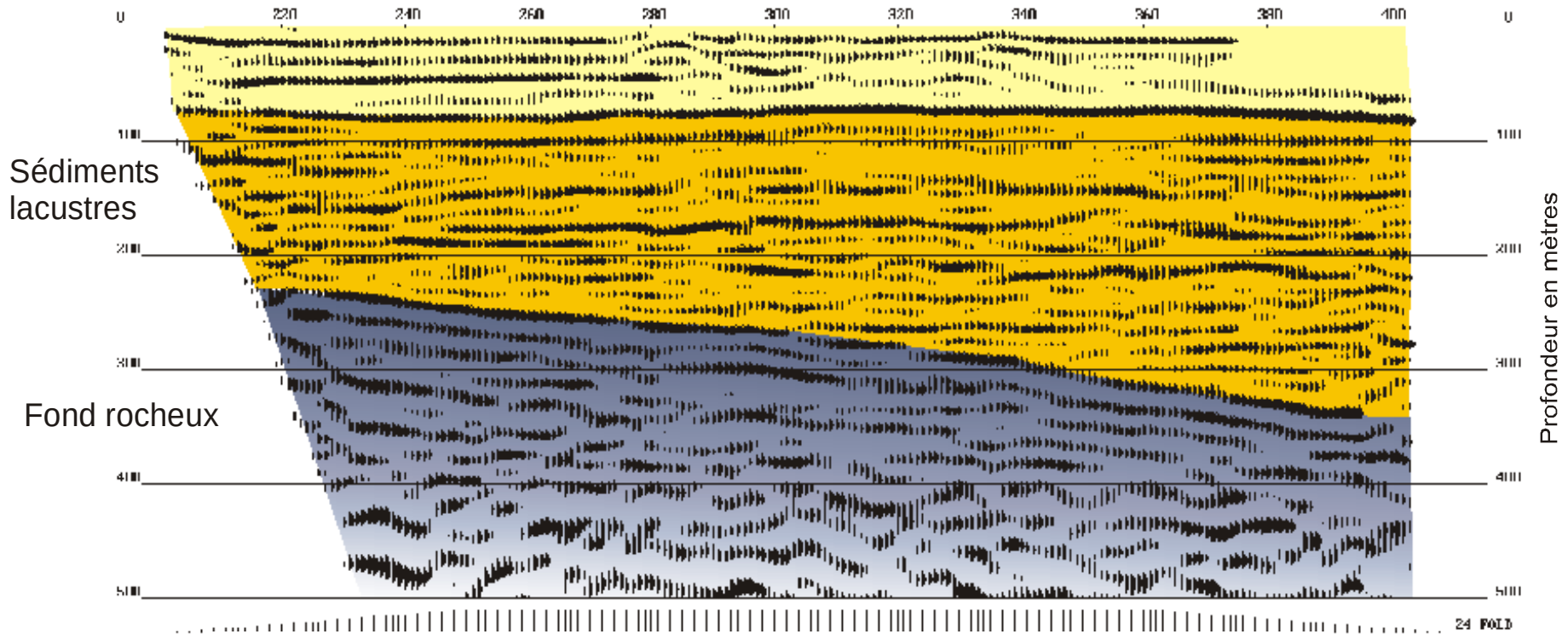



Fribourg (Switzerland)

- Geophone spacing 1 m Fold 24
- Energy Sledge hammer
- Investigation depth 20 m



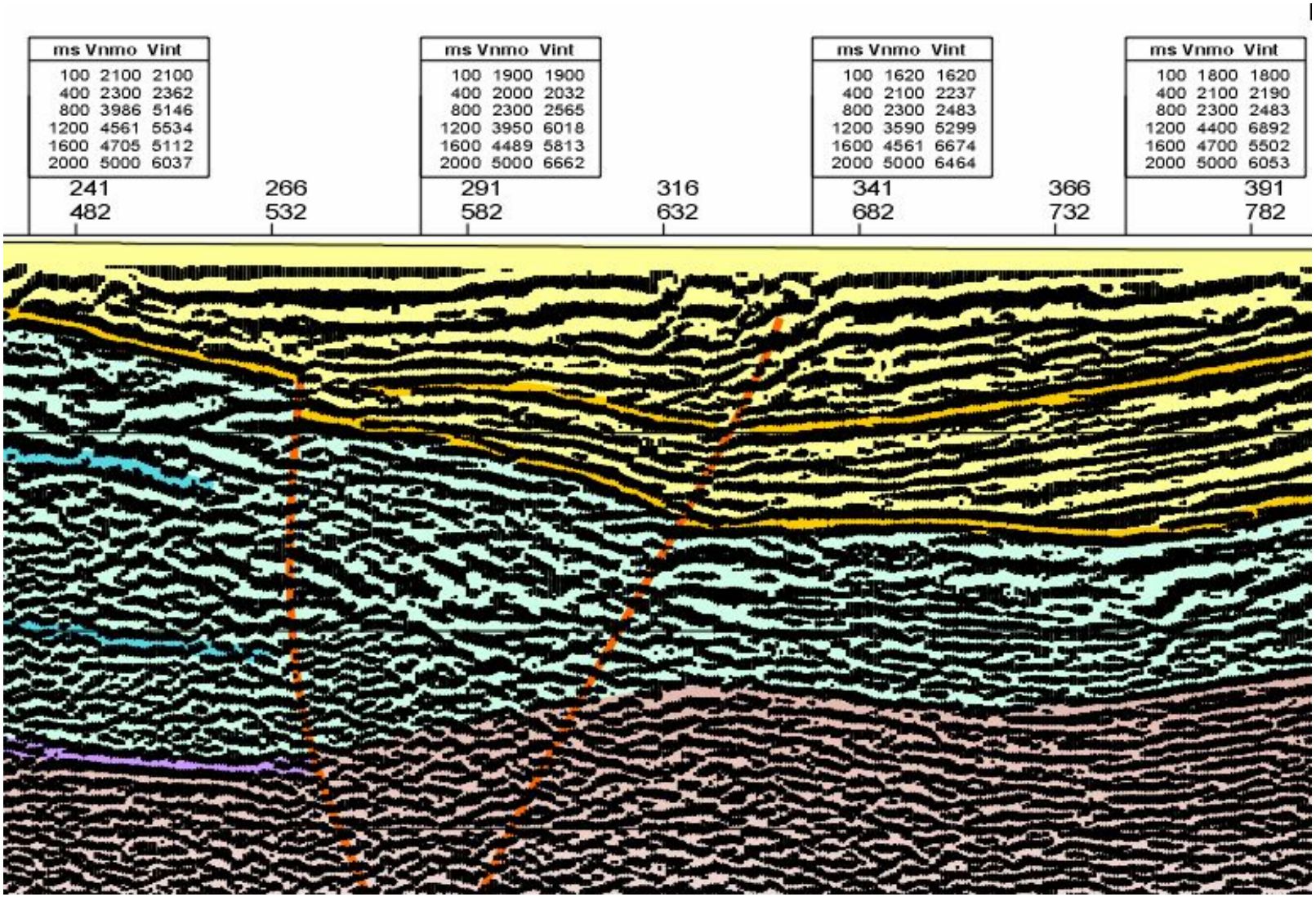
Rhone valley (CH): 2 m/trace, Buffalo gun fold 24



Distance / Depth section

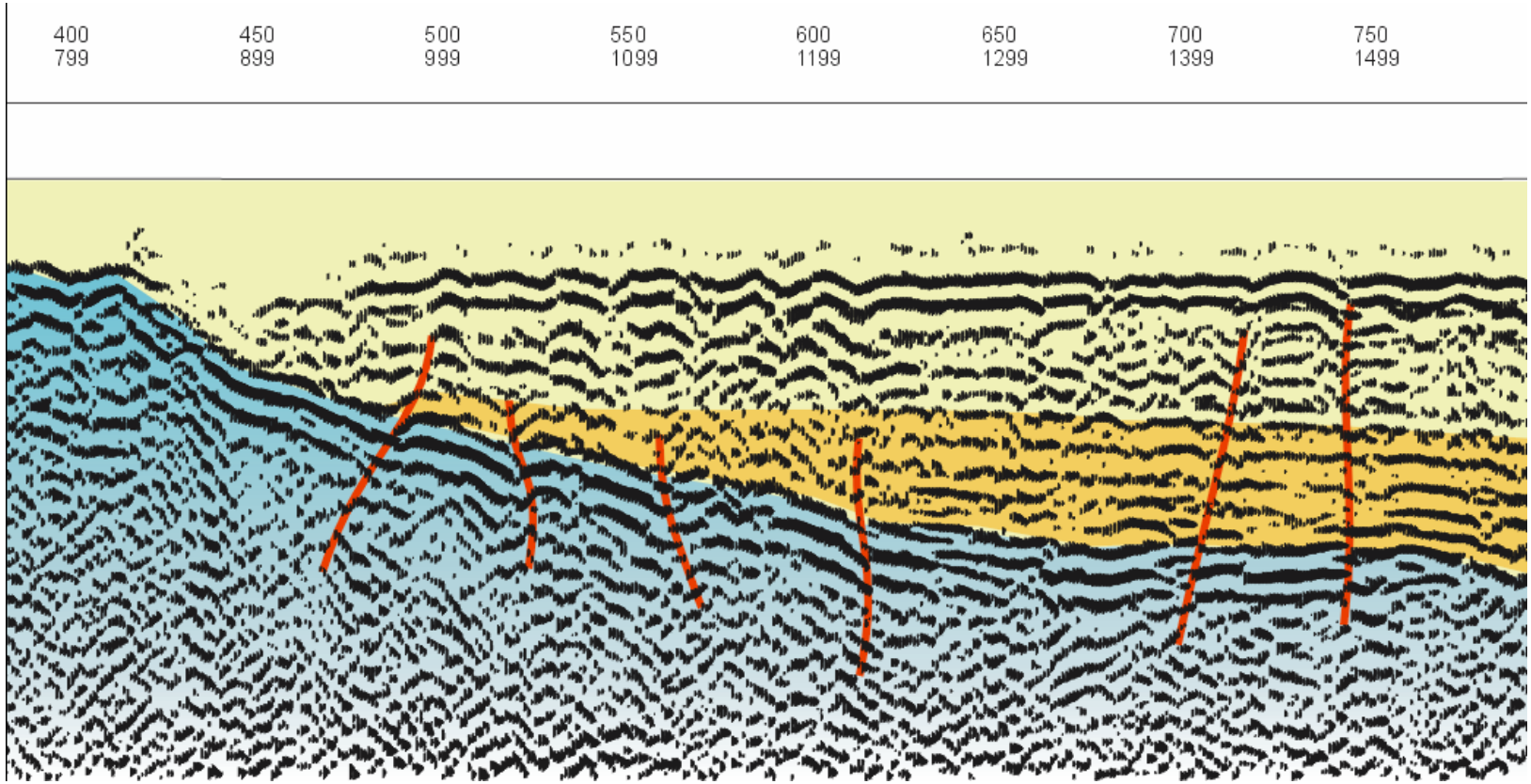
Morocco

5 vibrators, 15 m spacing, 60 channels,
12 geophones / string Scope: deep water



Quetta (Pakistan)

Shot/geophone spacing 5 m,
Energy 1 vibrator, 60 channels
Scope: deep water



Field pictures


Drilling

Loading explosive

Explosive (Sahara)


Recording truck


Jura field work

Vibrators Litton (Morocco)


Cables & geophones


PMU
Fin