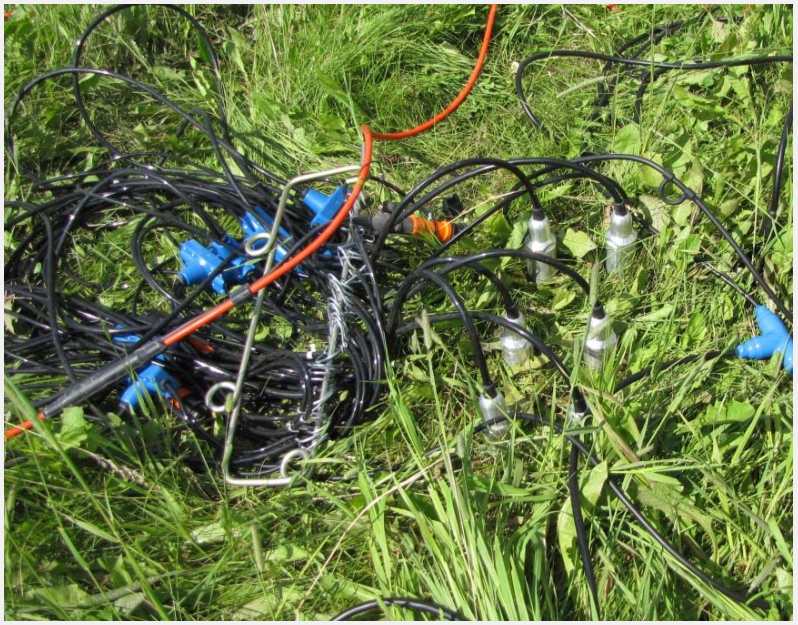
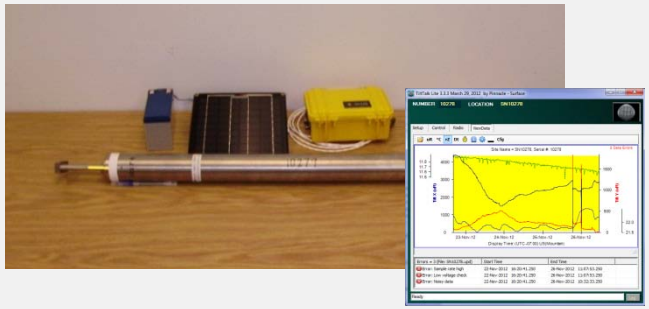
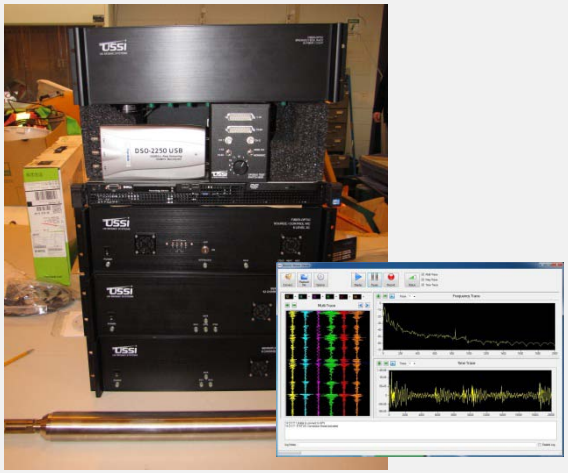
Recent fieldwork activities and analysis

Malcolm Bertram







CREWES

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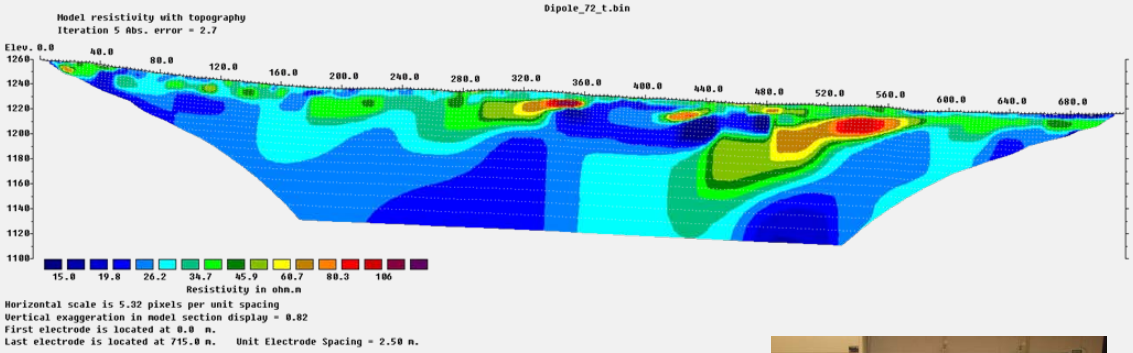
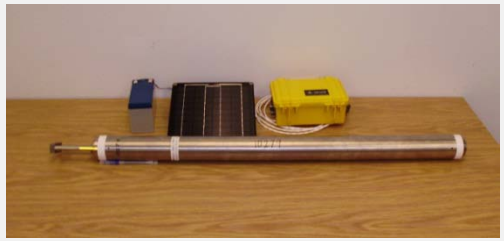
Covered in this talk

- The pulse-probe experiment
  - Sources
  - Sensors
  - Autoseis system

- Near surface survey
  - Aries
  - Geodes
  - Resisitivity

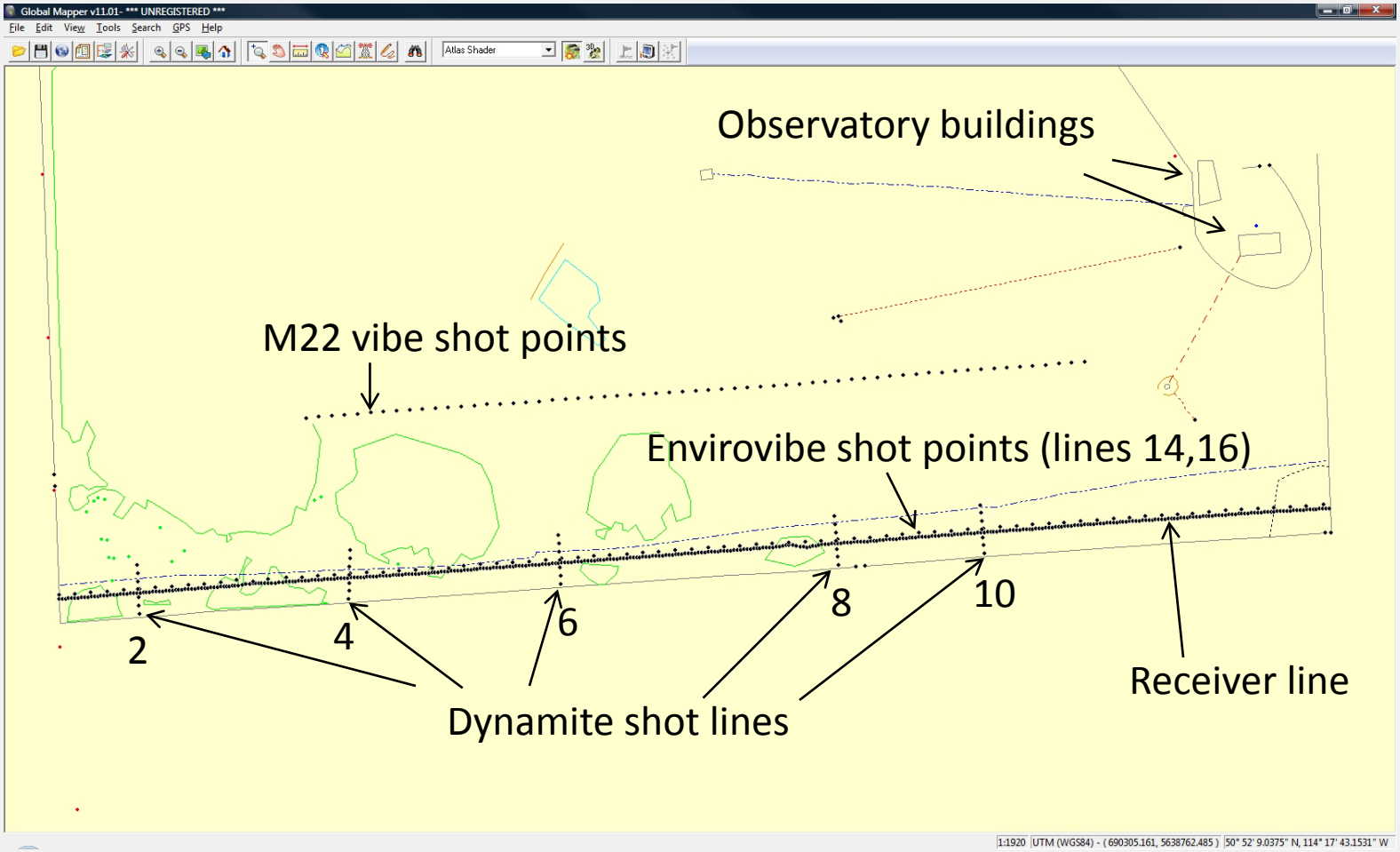


- New equipment
  - Shear wave thumper
  - Tiltmeters
  - Optical accelerometers



The pulse-probe experiment

Priddis test site 9 – 12 July 2012



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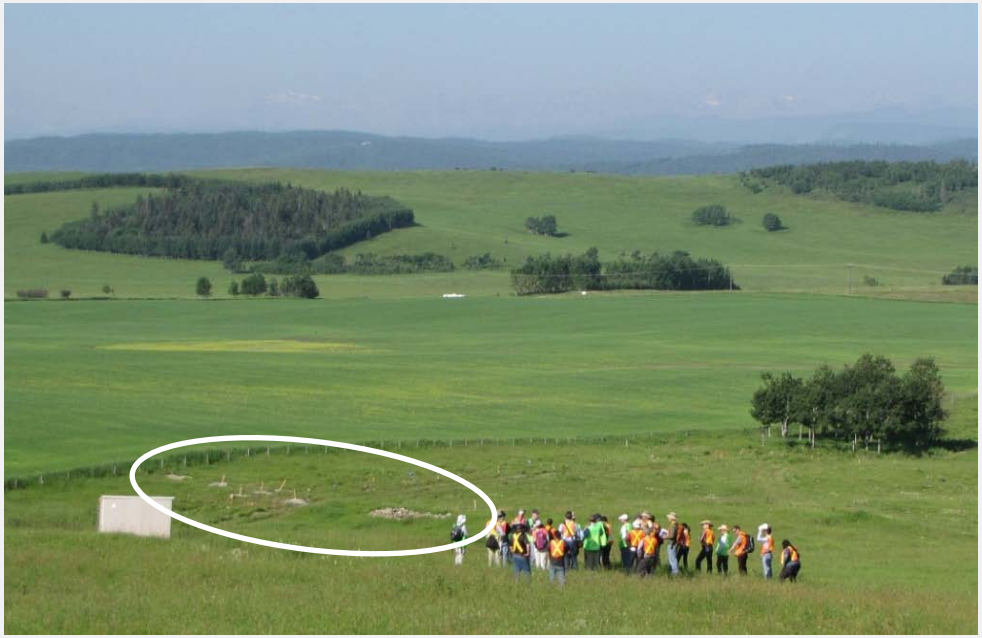
Sources

Dynamite shots on each line:

101	2 kg at 15 meters
102	0.5 kg at 15 meters
103	0.125 kg at 15 meters
104	2 caps at 15 meters
105	3 x 1 kg at 5 meters
106	0.25 kg at 15 meters
107	1 kg at 15 meters

See: Dynamite charge tests ... Chris Petten



Envirovibe

Line 14: Sweep 10 - 120 Hz linear over 10 seconds

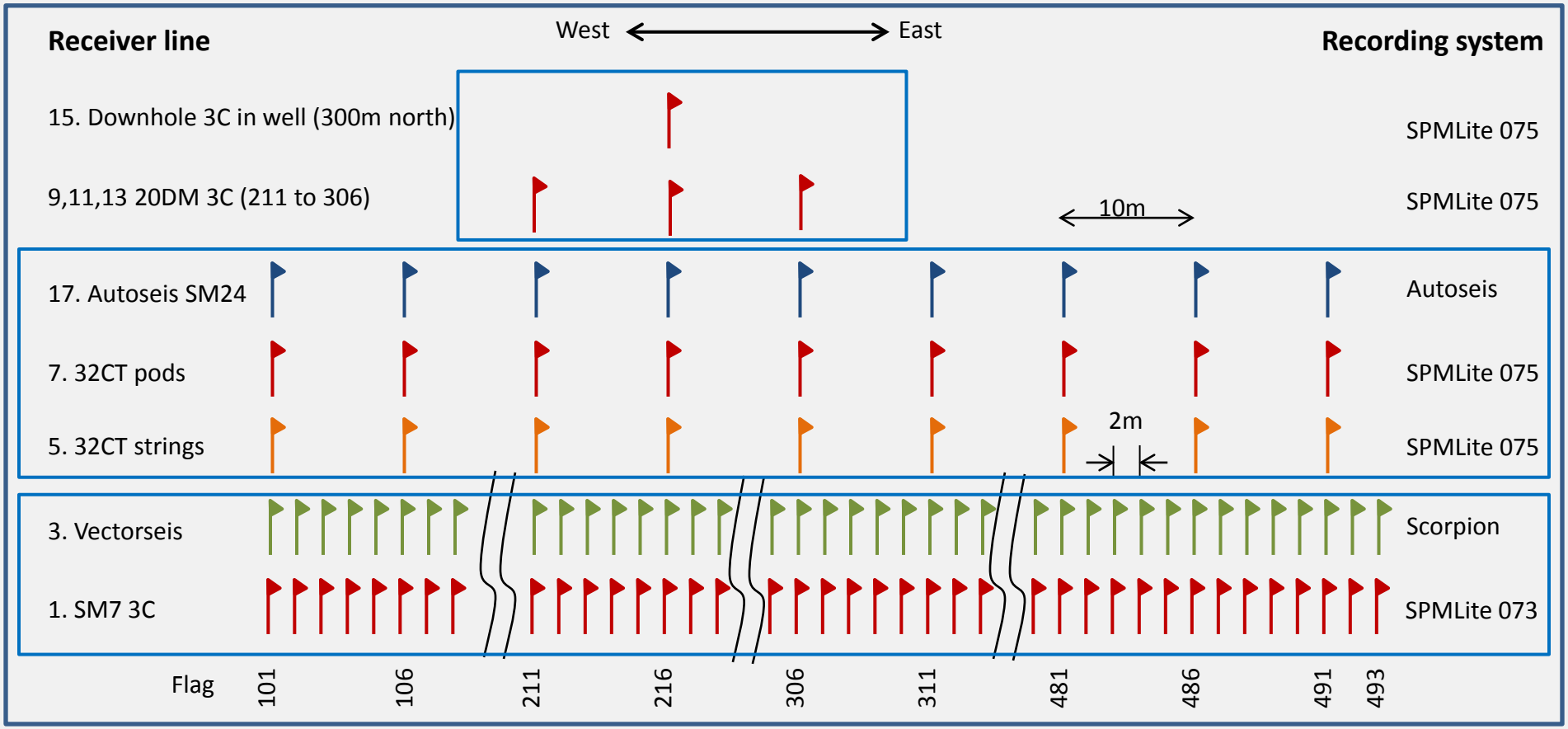
Line 16: Sweep 10 - 120 Hz linear over 10 seconds with 2 second delay

Mertz M22

Line 16: 25Hz mono-frequency sweep over 12 seconds

See: There's nonlinear and then there's nonlinear: Kris Innanen

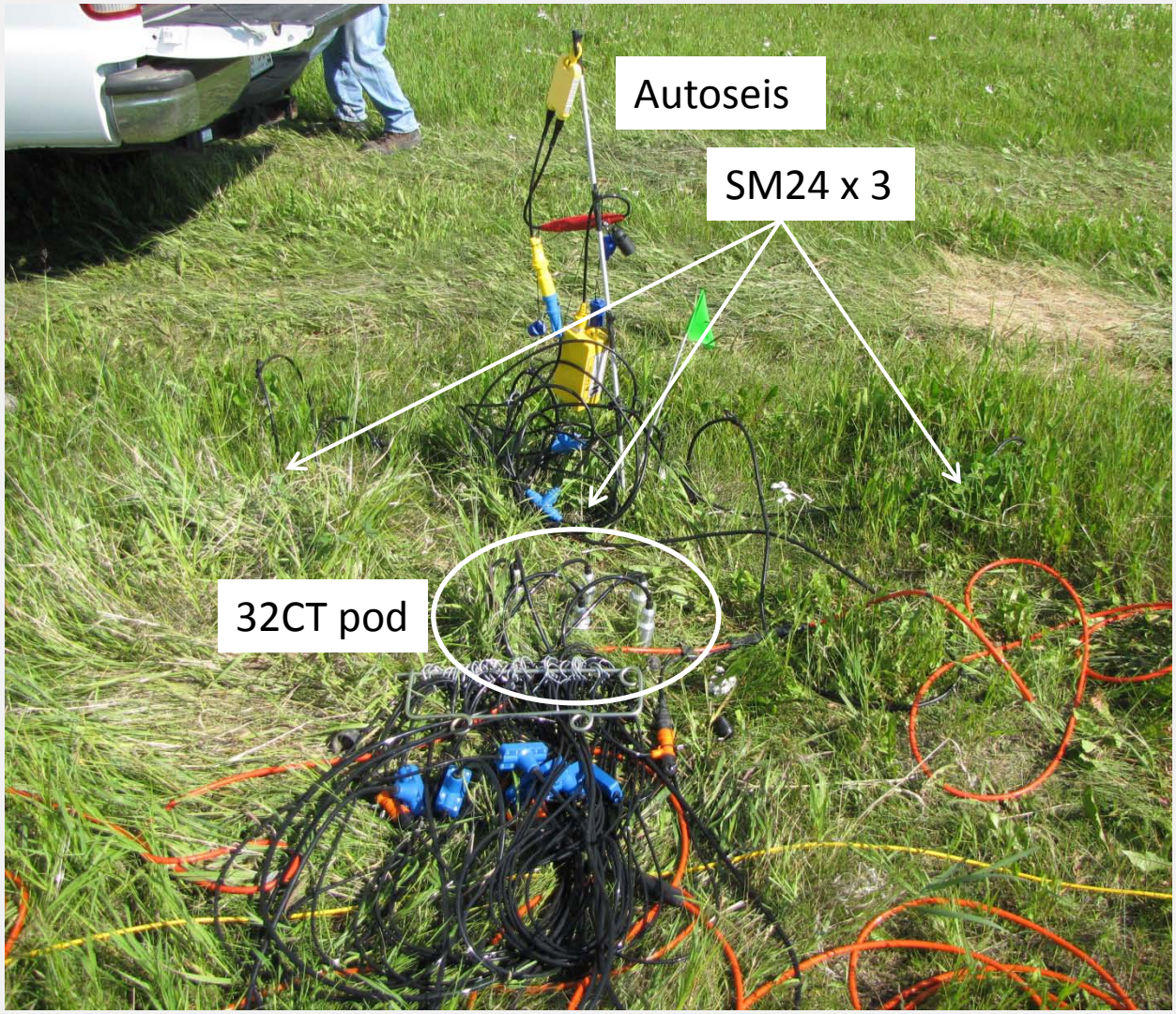
Receiver line layout



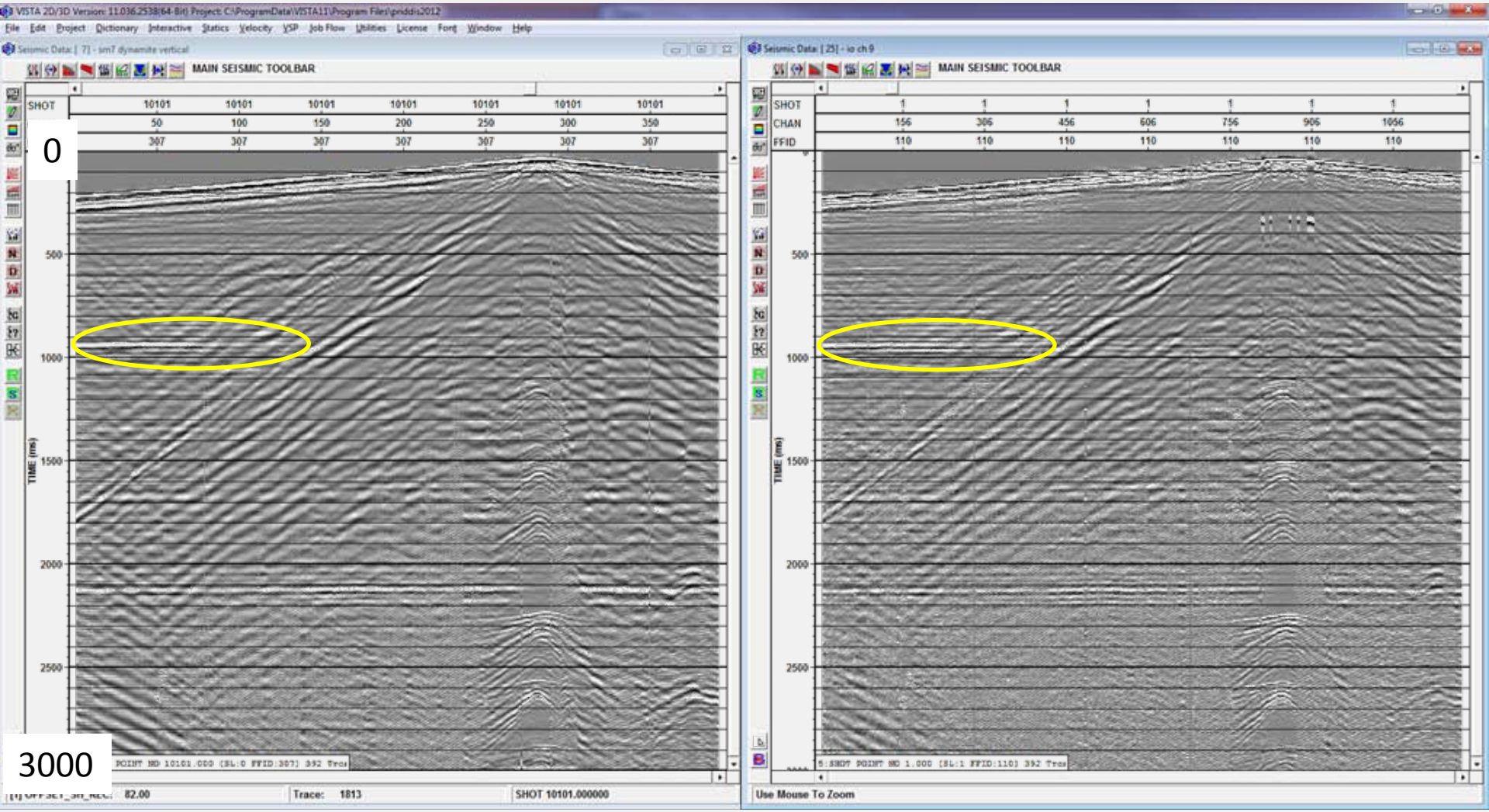
The usual confusion

	Sensor		Number	Spacing	Configuration	Recording system
Line 1:	SM7 3C	10Hz	single	2 m		SPMLite 073
Line 3:	Vectorseis 3C	MEMS	single	2 m		Scorpion
Line 5:	GS-32CT 1C	10Hz	6 over 10 m	10 m	(wired 3 x 2)	SPMLite 075
Line 7:	GS-32CT 1C	10Hz	6 bunched	10 m	(wired 3 x 2)	SPMLite 075
Line 9,11,13	GS-20DM 3C	10Hz	single	10 m	(under sandbags)	SPMLite 075
Line 15:	Geostuff 3C		single 3C	downhole geophone in well		SPMLite 075
Line 17:	SM24 1C	10Hz	3 over 1 m	10 m	(wired 3 in series)	Autoseis

Sensors



Shot gathers for shot 10101 – 2 kg at 15 m



Aries SM7 Vectorseis

Vertical component. Filtered 10-15-100-120 Hz

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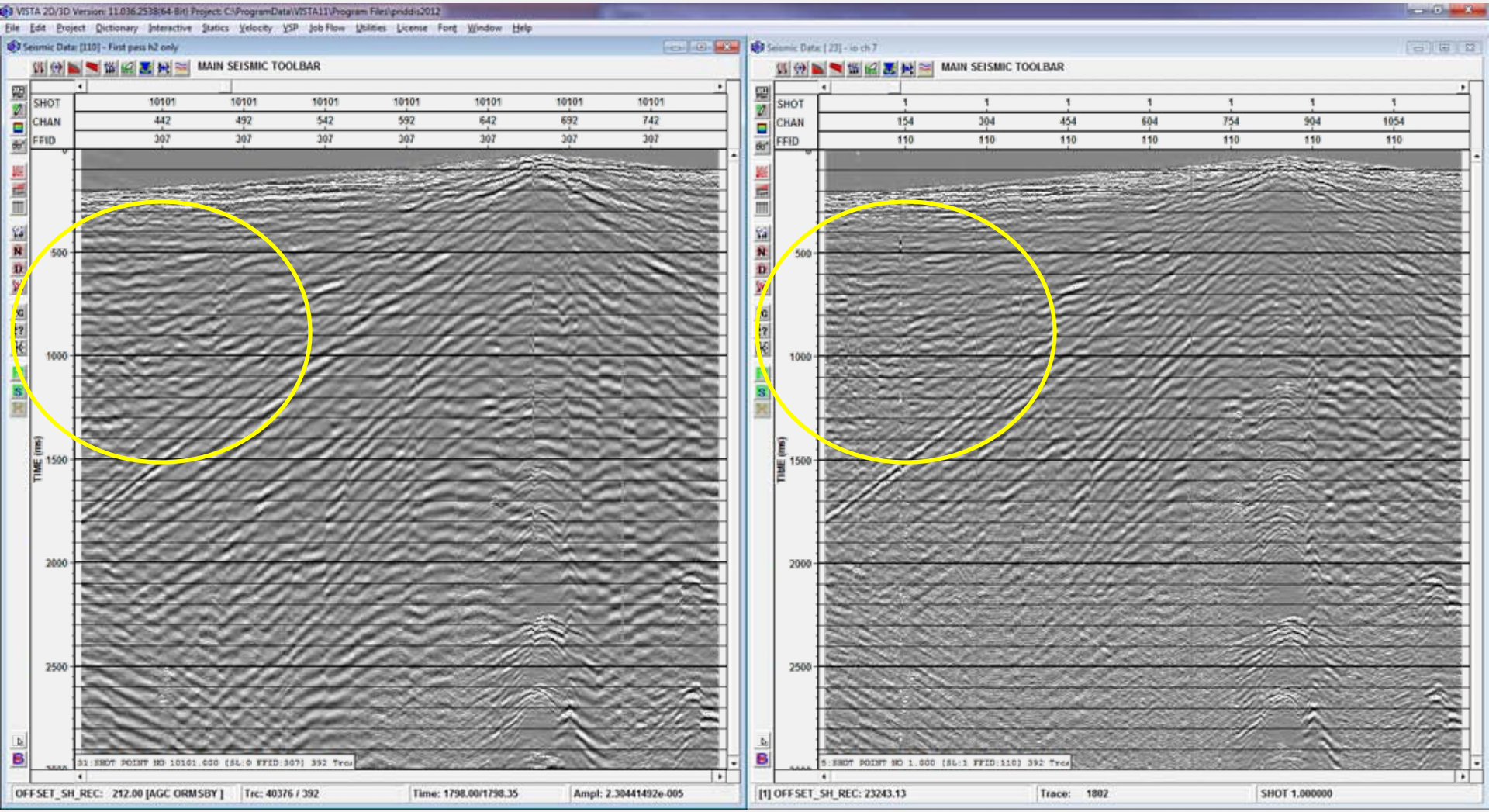
Shot gathers for shot 10101 – 2 kg at 15 m



Aries SM7 Vectorseis

Radial component. Filtered 10-15-100-120 Hz

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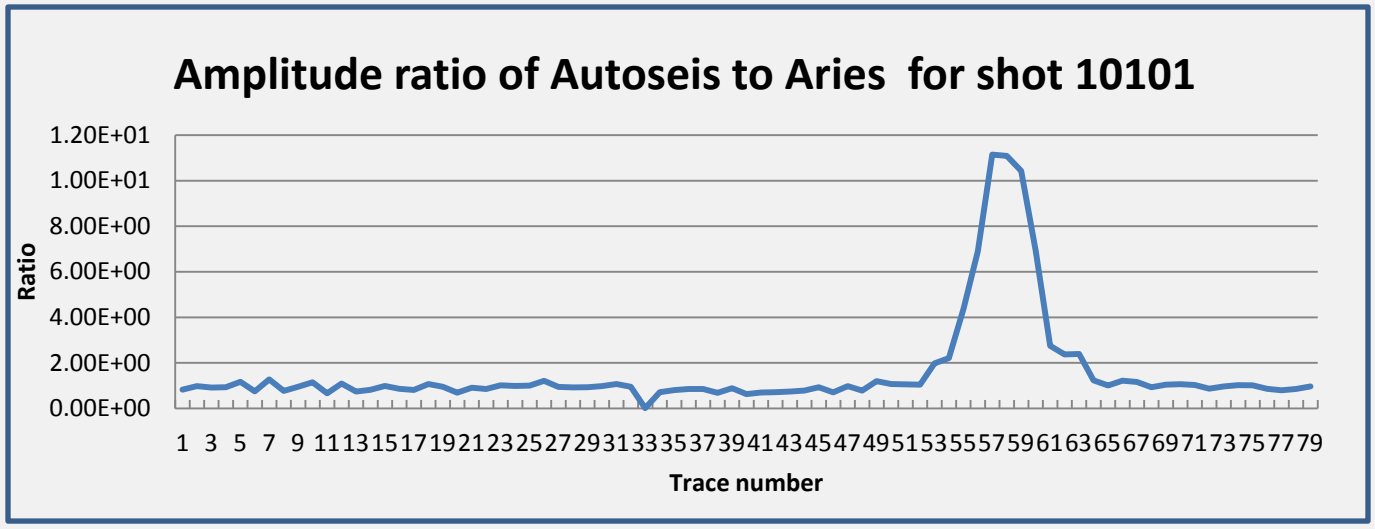
Comparing the data converters

Parameter	Aries	Autoseis
Number of bits	24 (23 + sign)	32 (31 + sign)
Max converter input (spec) (volts)	4.725	2.5
Hex code for max	53FFFF (5505023)	7FFFFFFF (2147483647)
Max system input (spec) (volts)	0.1708 (@30db gain)	2.5
Max input (observed) (volts)	0.223 (=7FFFFF)	2.5 (=7FFFFFFF)
Data format	32 bit IEEE floating point	32 bit 2's complement integer
Data values in file	System input voltage	Uncorrected integer
Correction required	None	1.164153218E-9 (2.5/2^31)
Value of lsb (at system input)	26.822095 nv	1.164153218 nv



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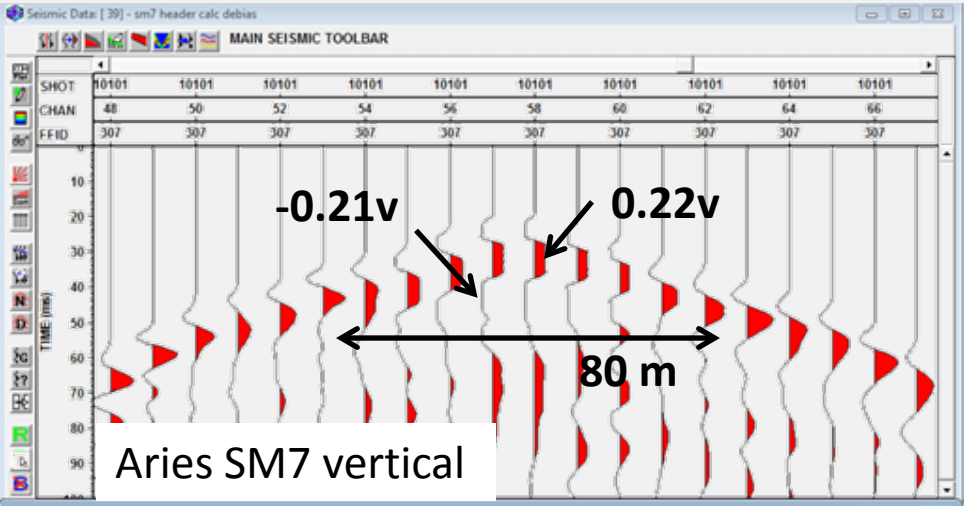
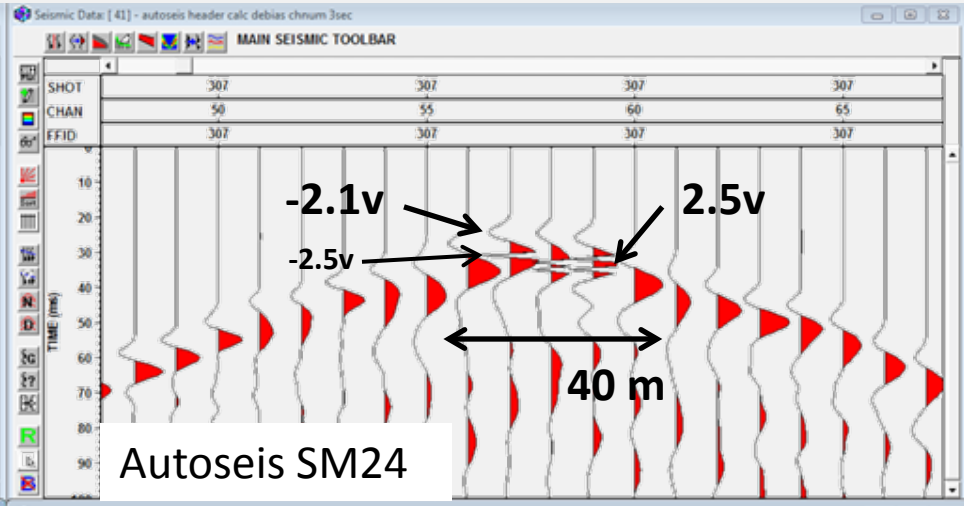
Data clipping at near offsets

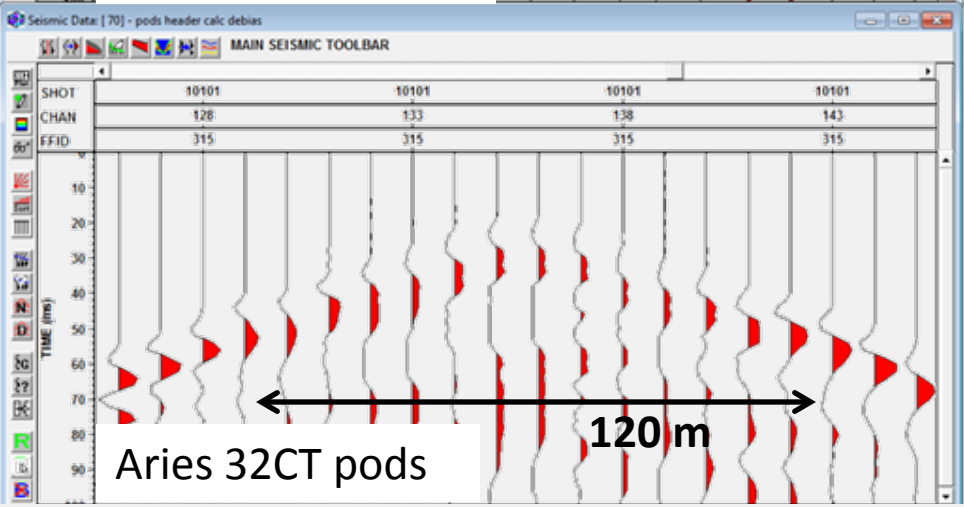
Shot 10101 2 kg @ 15m



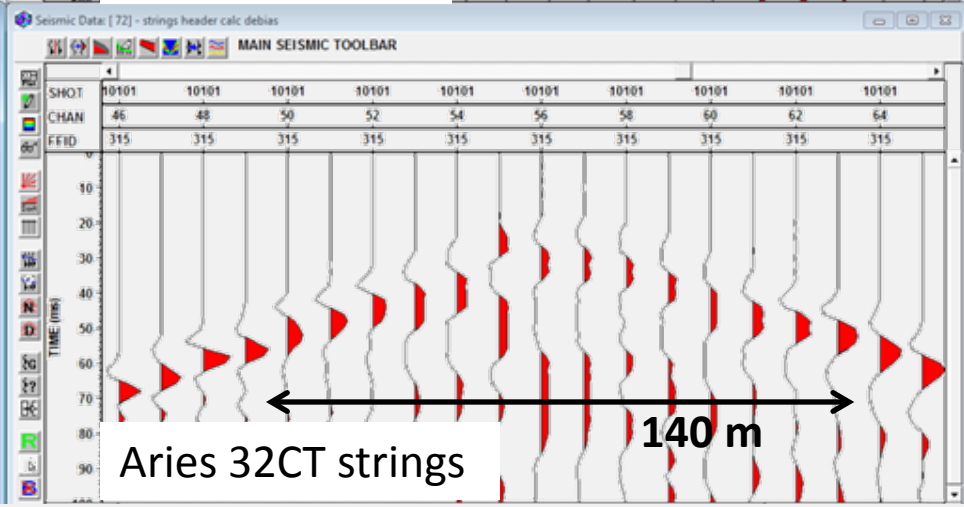
Aries SM7 vertical



Autoseis SM24



Aries 32CT pods



Aries 32CT strings

Bit levels for the Aries and Autoseis

Voltage per bit

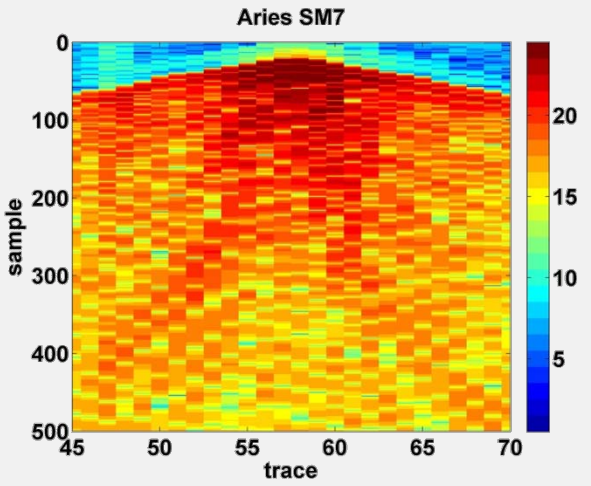
Bit	Autoseis
32	2.50000E+00
31	1.25000E+00
30	6.25000E-01
29	3.12500E-01
28	1.56250E-01
27	7.81250E-02
26	3.90625E-02
25	1.95313E-02
24	9.76563E-03
23	4.88281E-03
22	2.44141E-03
21	1.22070E-03
20	6.10352E-04
19	3.05176E-04
18	1.52588E-04
17	7.62939E-05
16	3.81470E-05
15	1.90735E-05
14	9.53674E-06
13	4.76837E-06
12	2.38419E-06
11	1.19209E-06
10	5.96046E-07
9	2.98023E-07
8	1.49012E-07
7	7.45058E-08
6	3.72529E-08
5	1.86265E-08
4	9.31323E-09
3	4.65661E-09
2	2.32831E-09
1	1.16415E-09

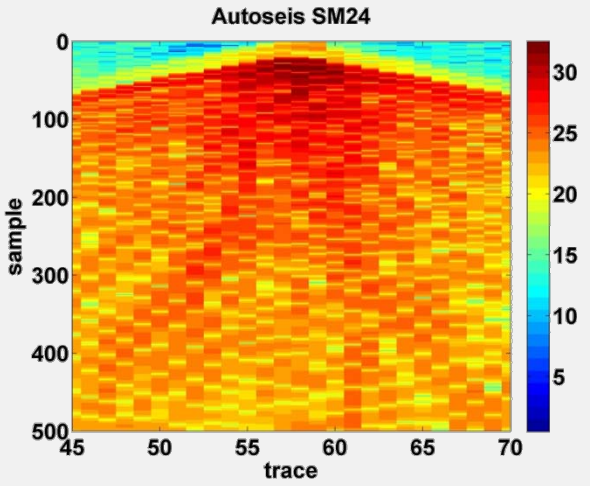
Aries	Bit
2.20000E-01	24
1.10000E-01	23
5.50000E-02	22
2.75000E-02	21
1.37500E-02	20
6.87500E-03	19
3.43750E-03	18
1.71875E-03	17
8.59375E-04	16
4.29688E-04	15
2.14844E-04	14
1.07422E-04	13
5.37109E-05	12
2.68555E-05	11
1.34277E-05	10
6.71387E-06	9
3.35693E-06	8
1.67847E-06	7
8.39233E-07	6
4.19617E-07	5
2.09808E-07	4
1.04904E-07	3
5.24521E-08	2
2.62260E-08	1

Deriving the bit level

$$\text{bit} = log2(ABS\left(\frac{V}{V_{max}} * 2^{n-1}\right))$$

V	sample voltage
$Vmax$	observed clip level
n	number of bits (24 or 32)





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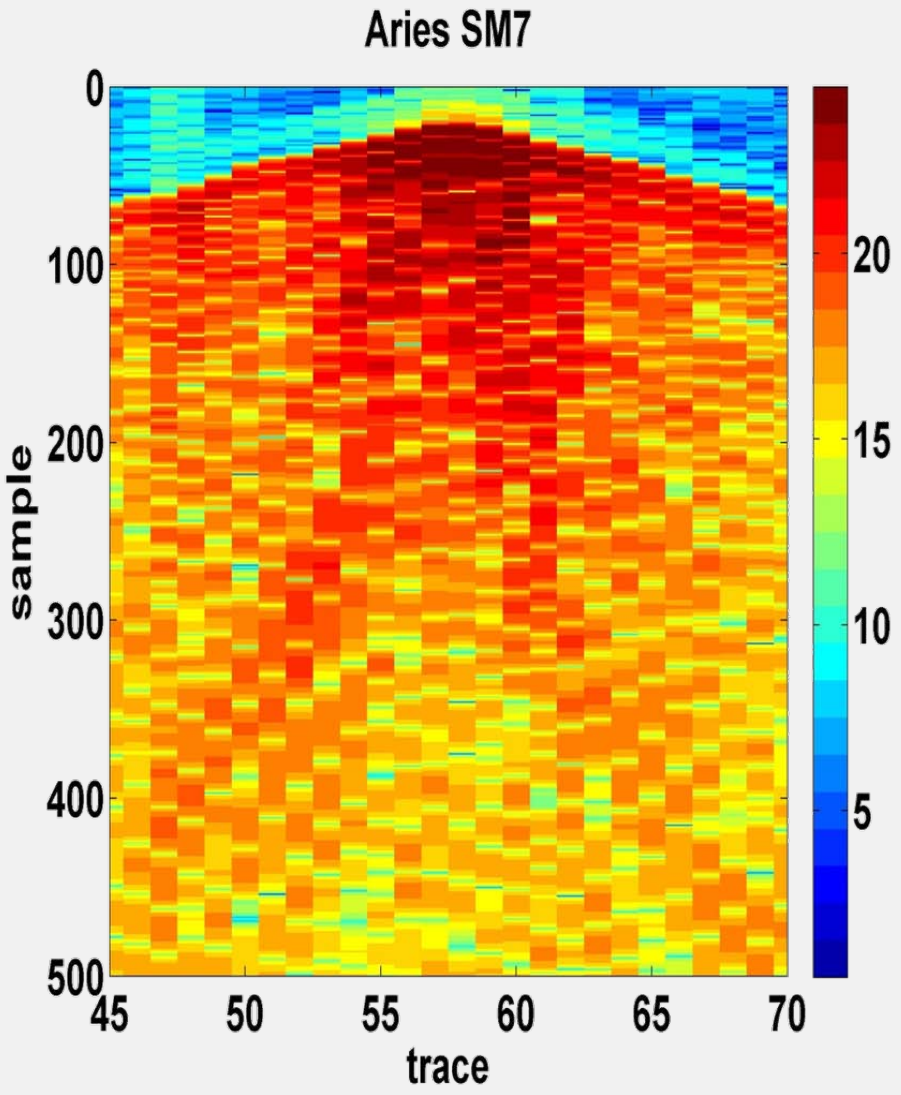
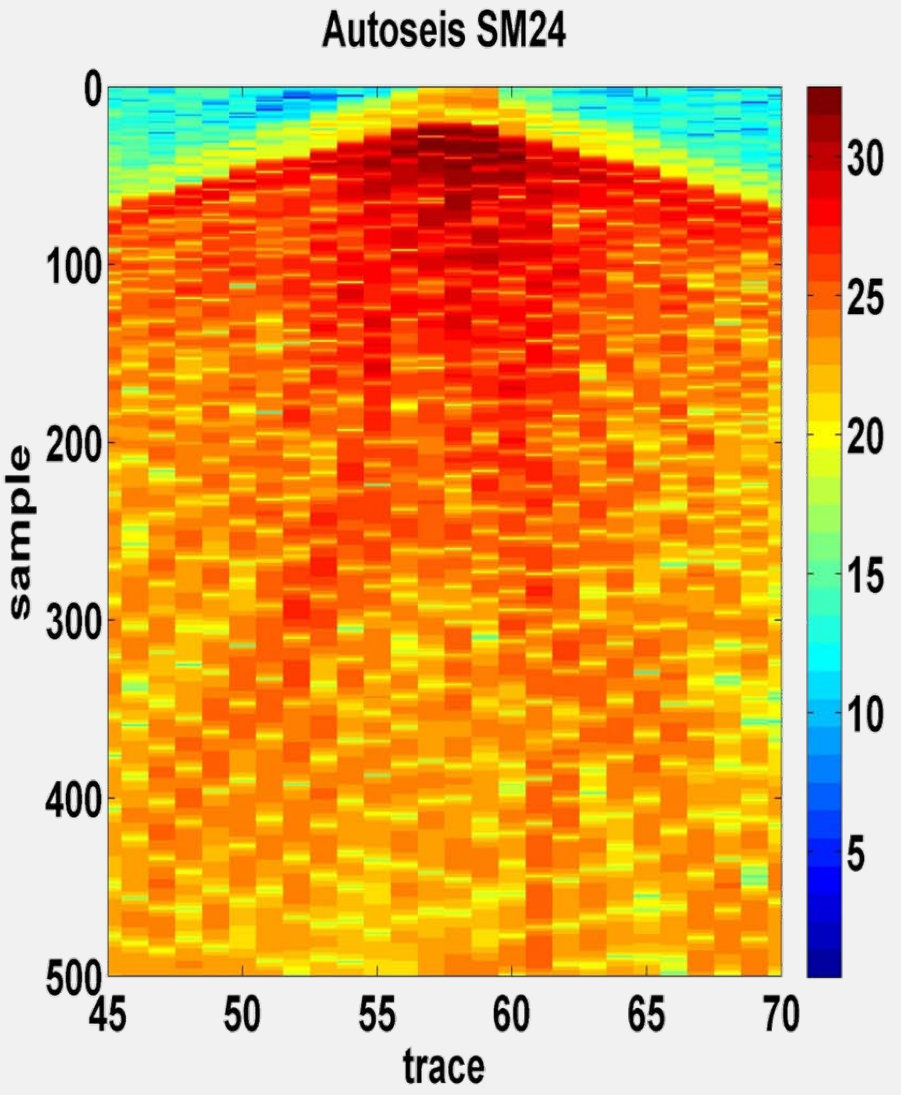
Bit level plots for near offsets





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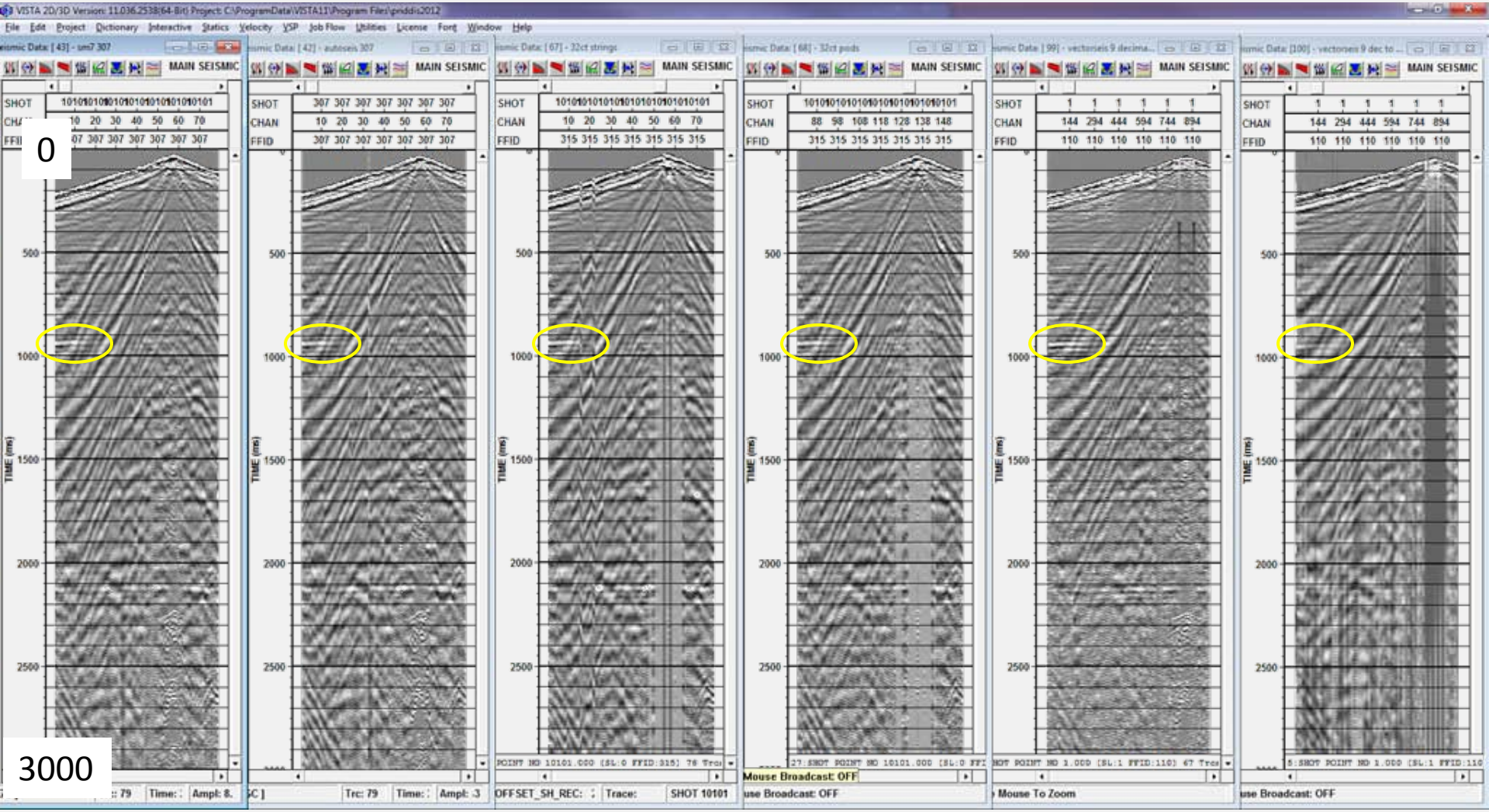
Shot gathers for shot 10101 – 2 kg at 15 m



Aries SM7 and Vectorseis decimated to 10m spacing.

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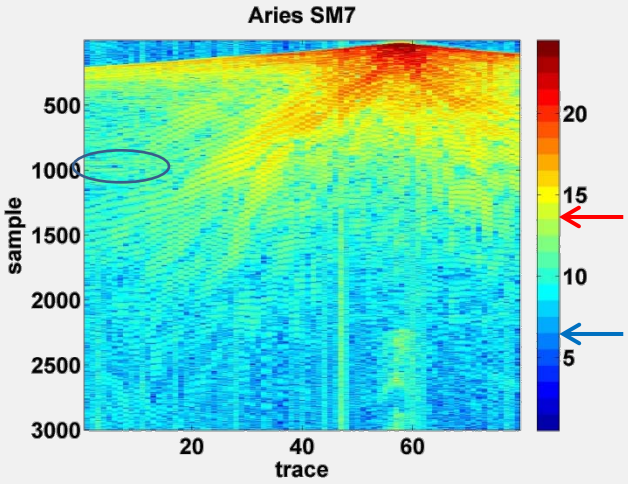
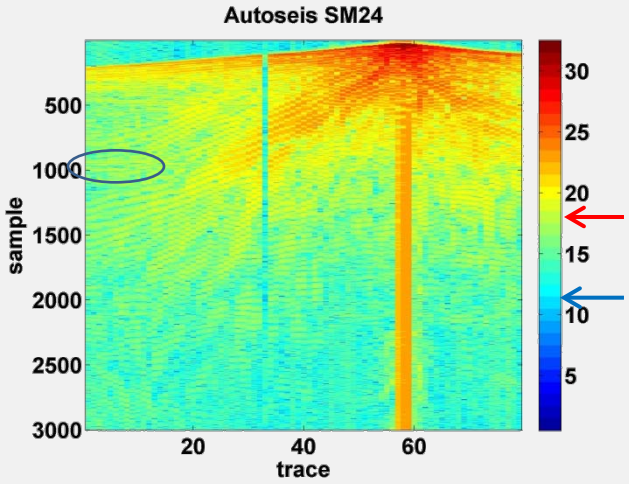
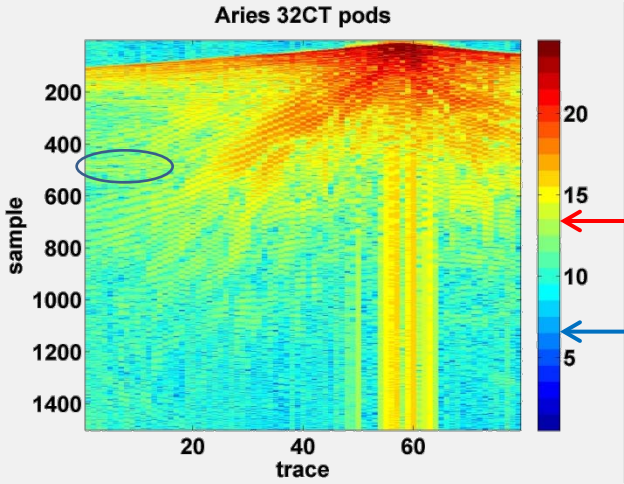
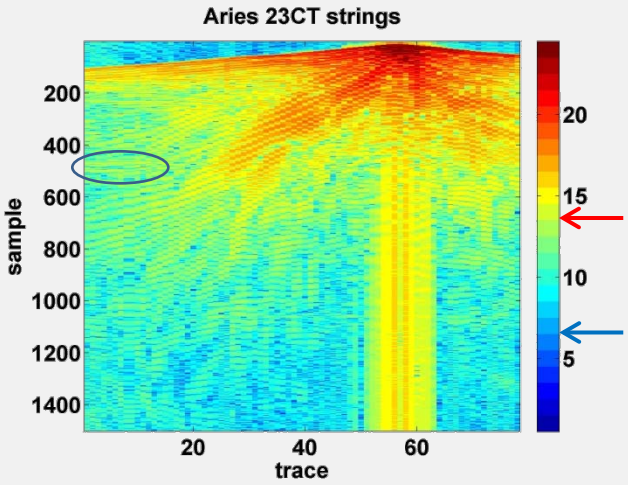
Bit levels for the different systems

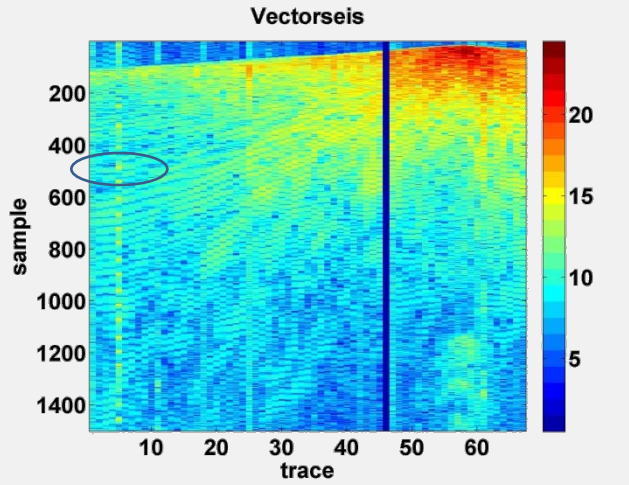
Shot 10101 2 kg @ 15m

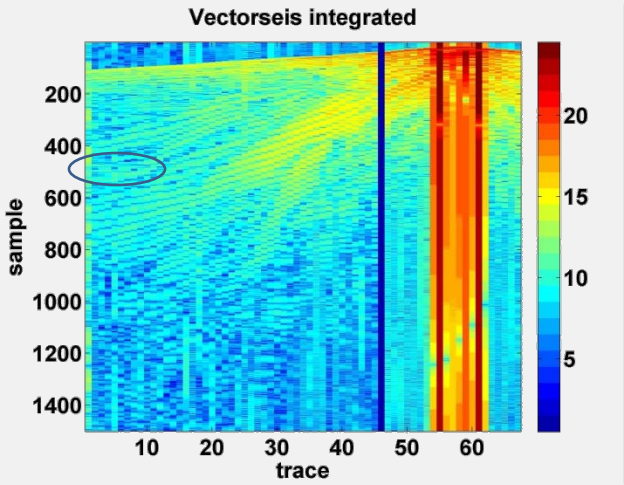












Blue arrows show colour level for 1 μV
Red arrows show colour level for 100 μV

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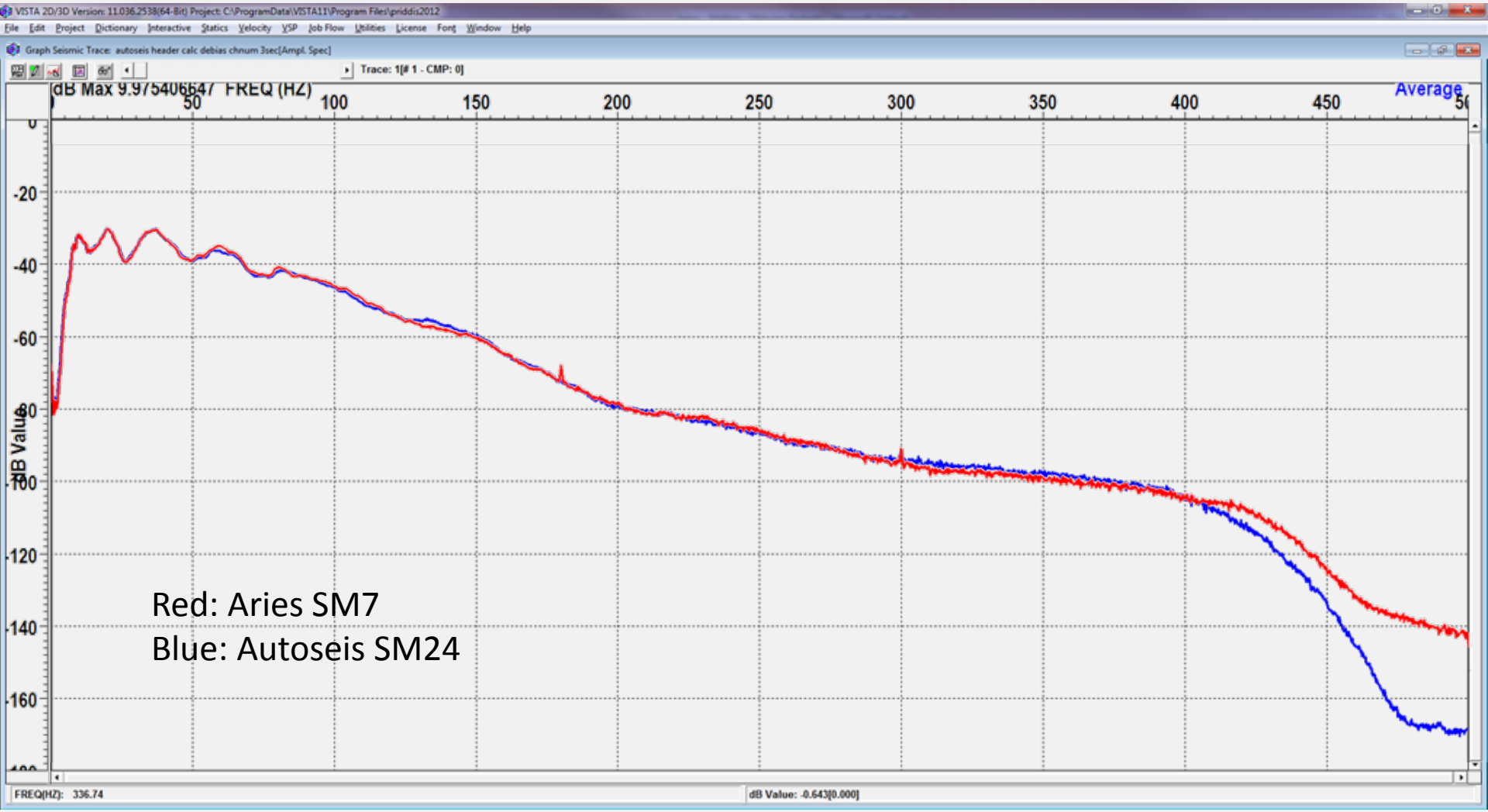
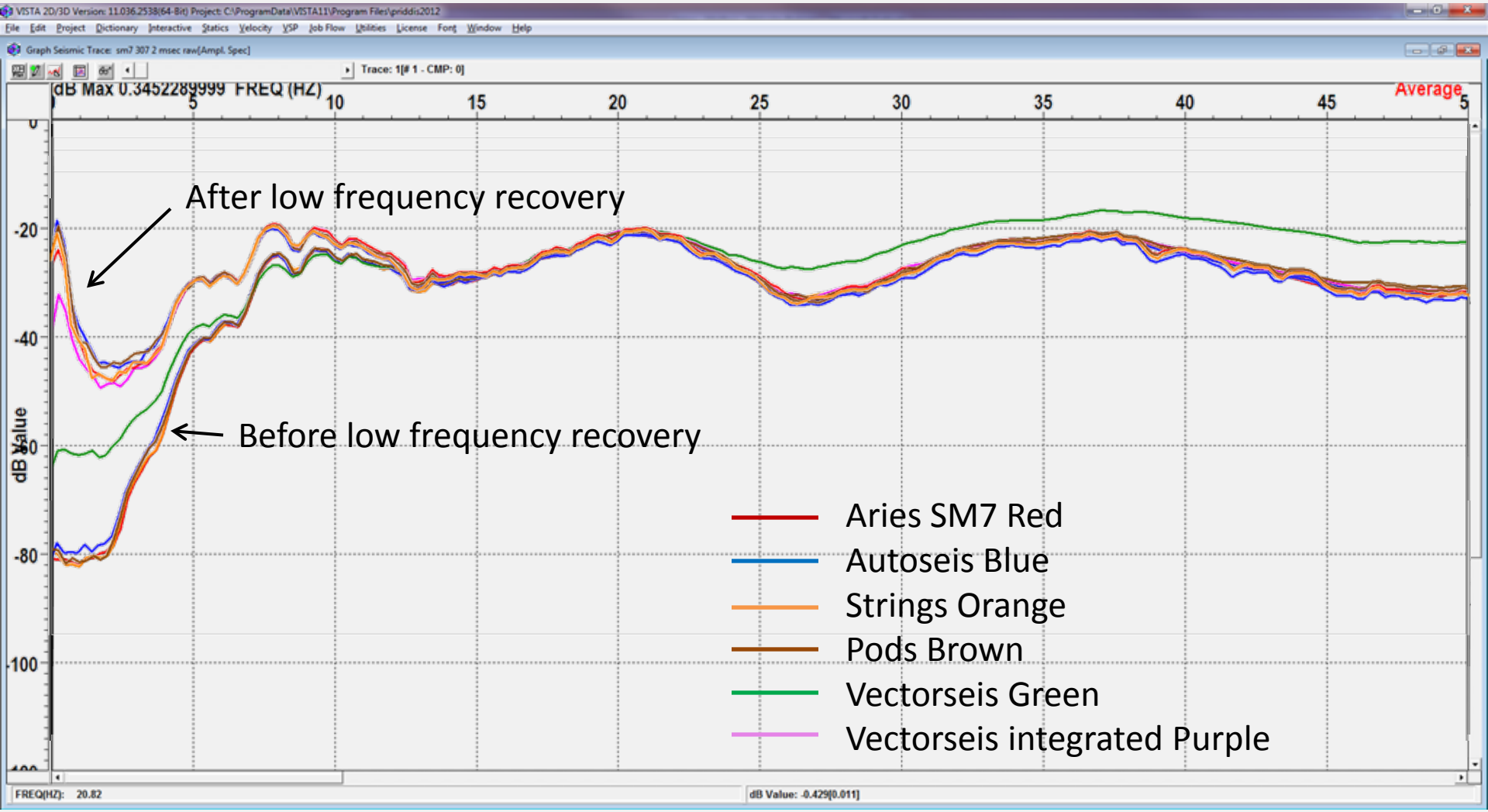
Spectra for shot 10101 – 2 kg at 15 m



Spectra of 10101 (File 307). Whole gather.

Spectra for shot 10101 – 2 kg at 15 m



Spectra for the first 50 traces of the gather

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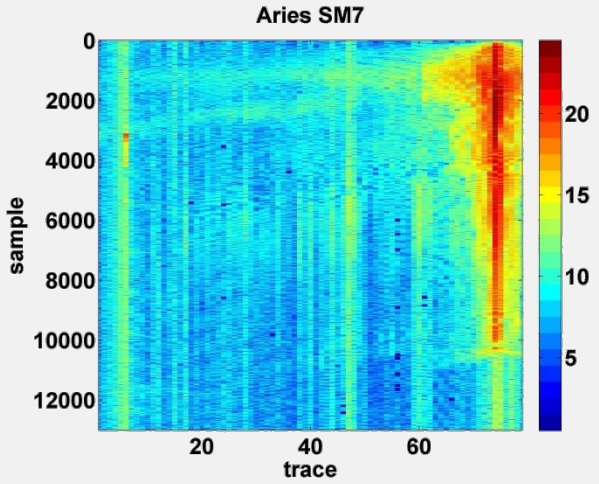
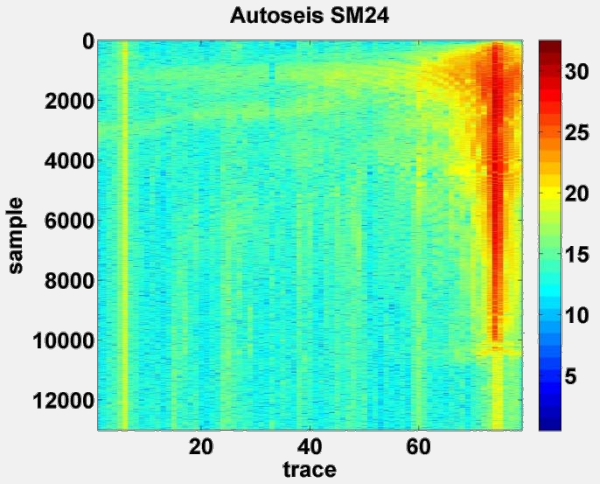
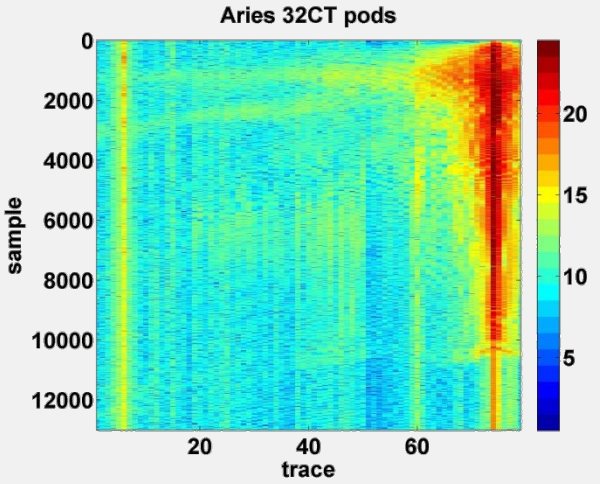
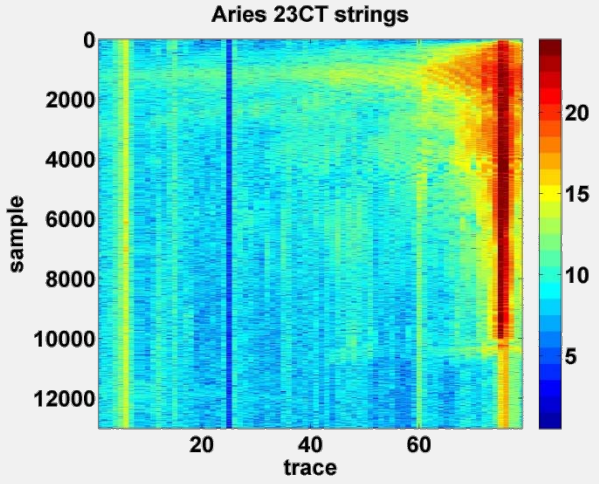
Vibrator gathers for Envirovibe

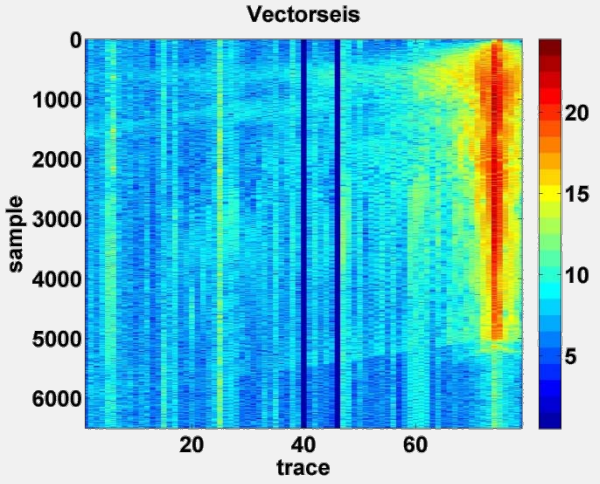
Vibe point 14467. Envirovibe only

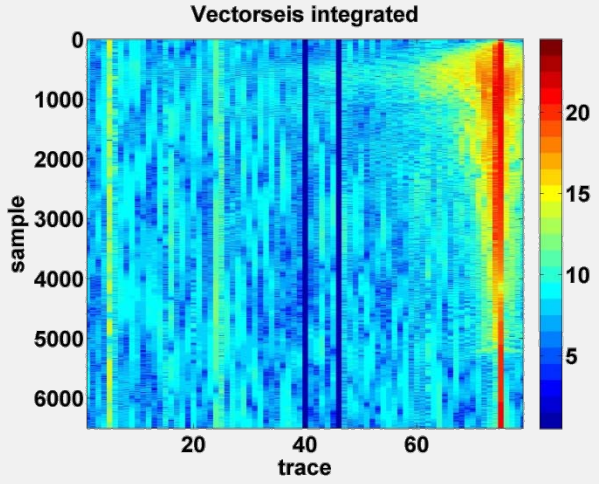












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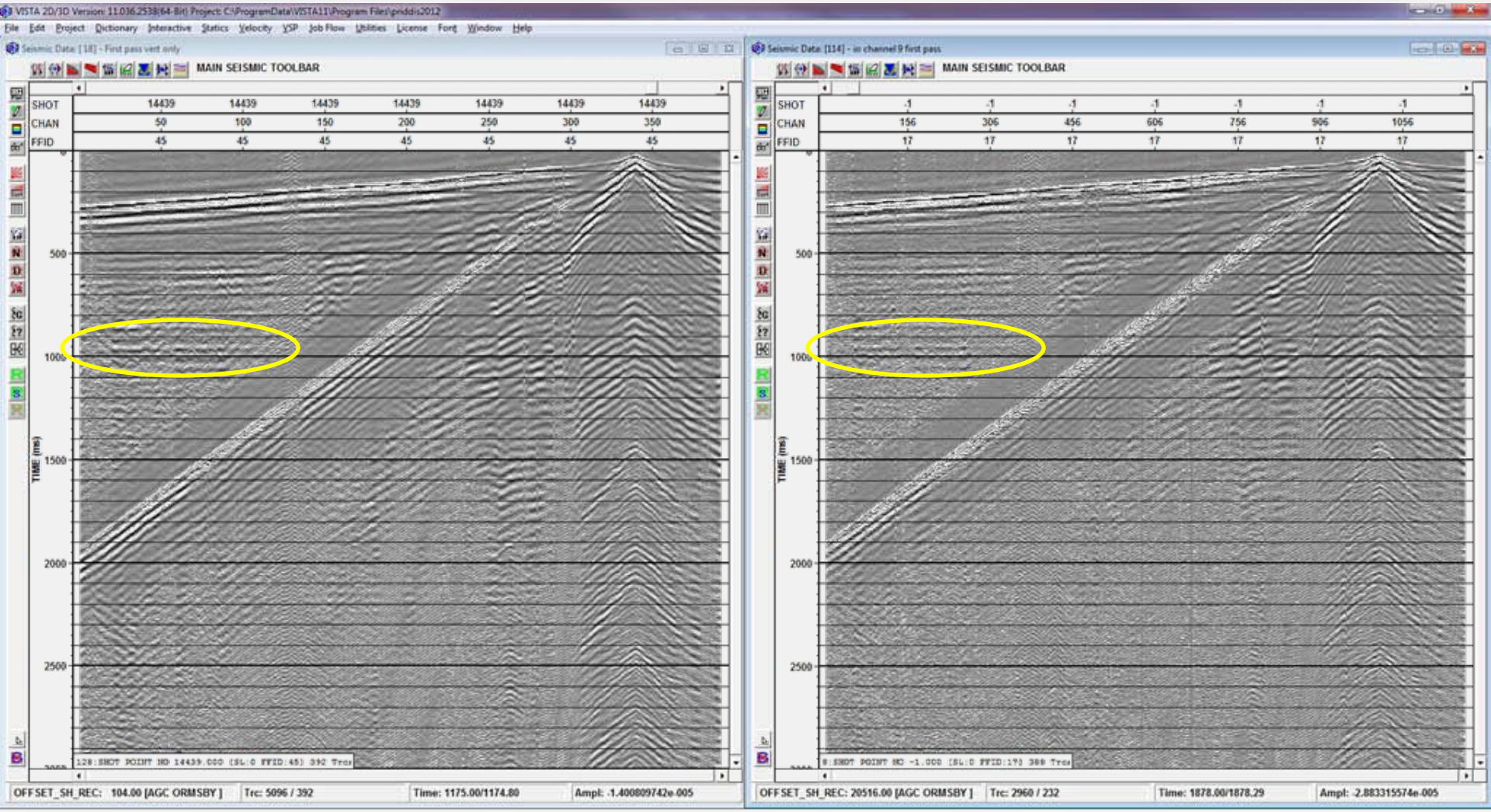
Correlated gathers from 14439

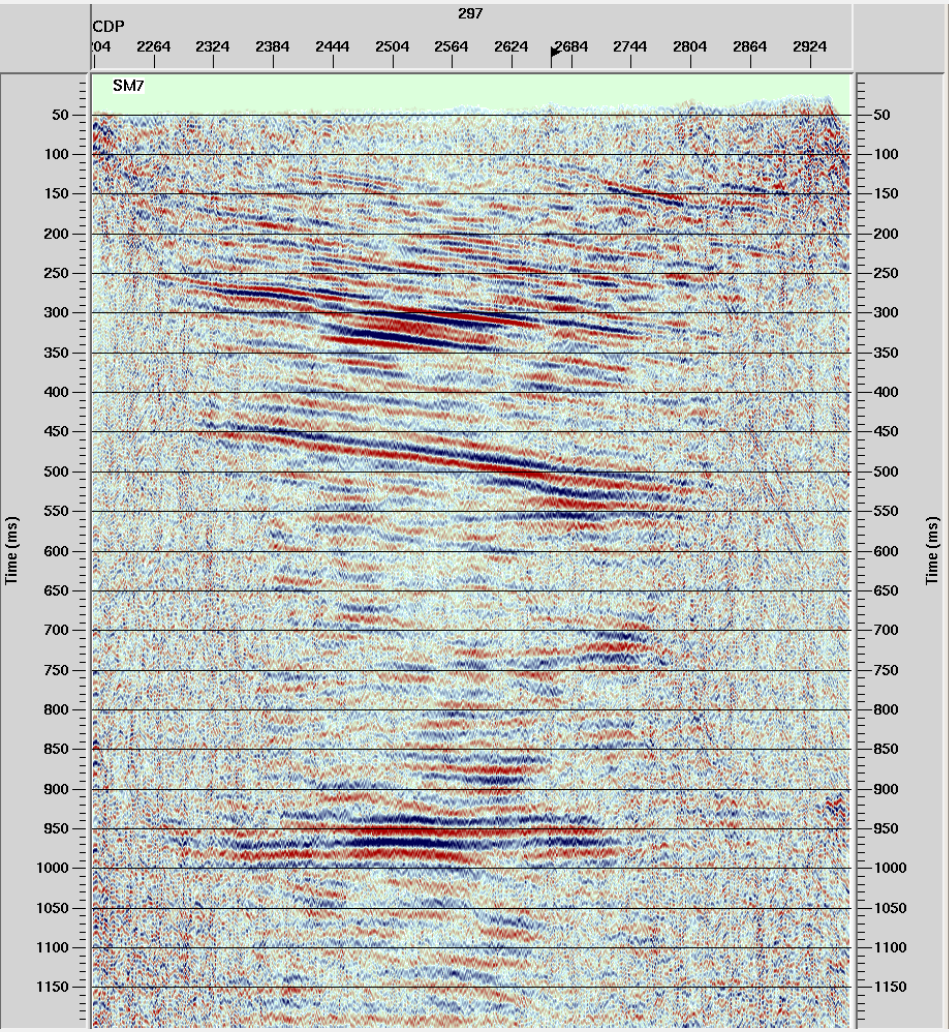


Aries SM7 Vectorseis

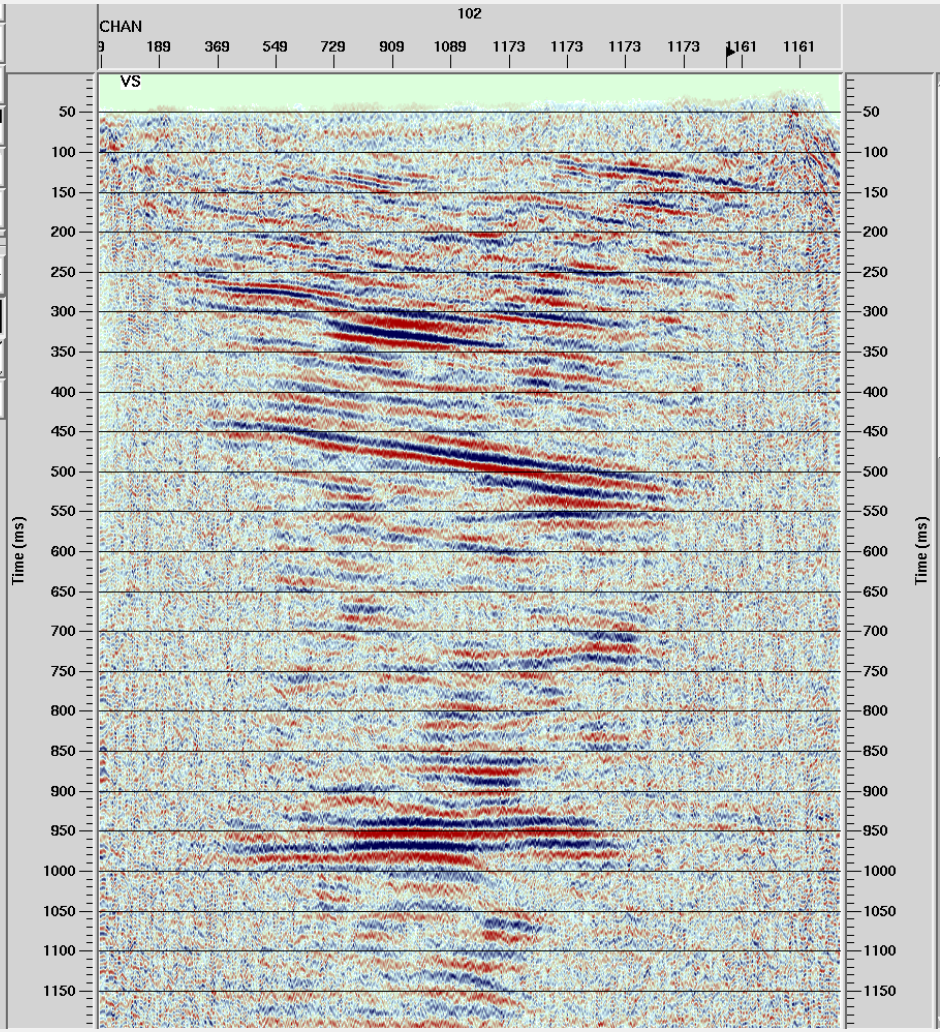
Vertical component. Filtered 15-20-100-120 Hz

CREWES

Section from Envirovibe



Aries SM7



Vectorseis

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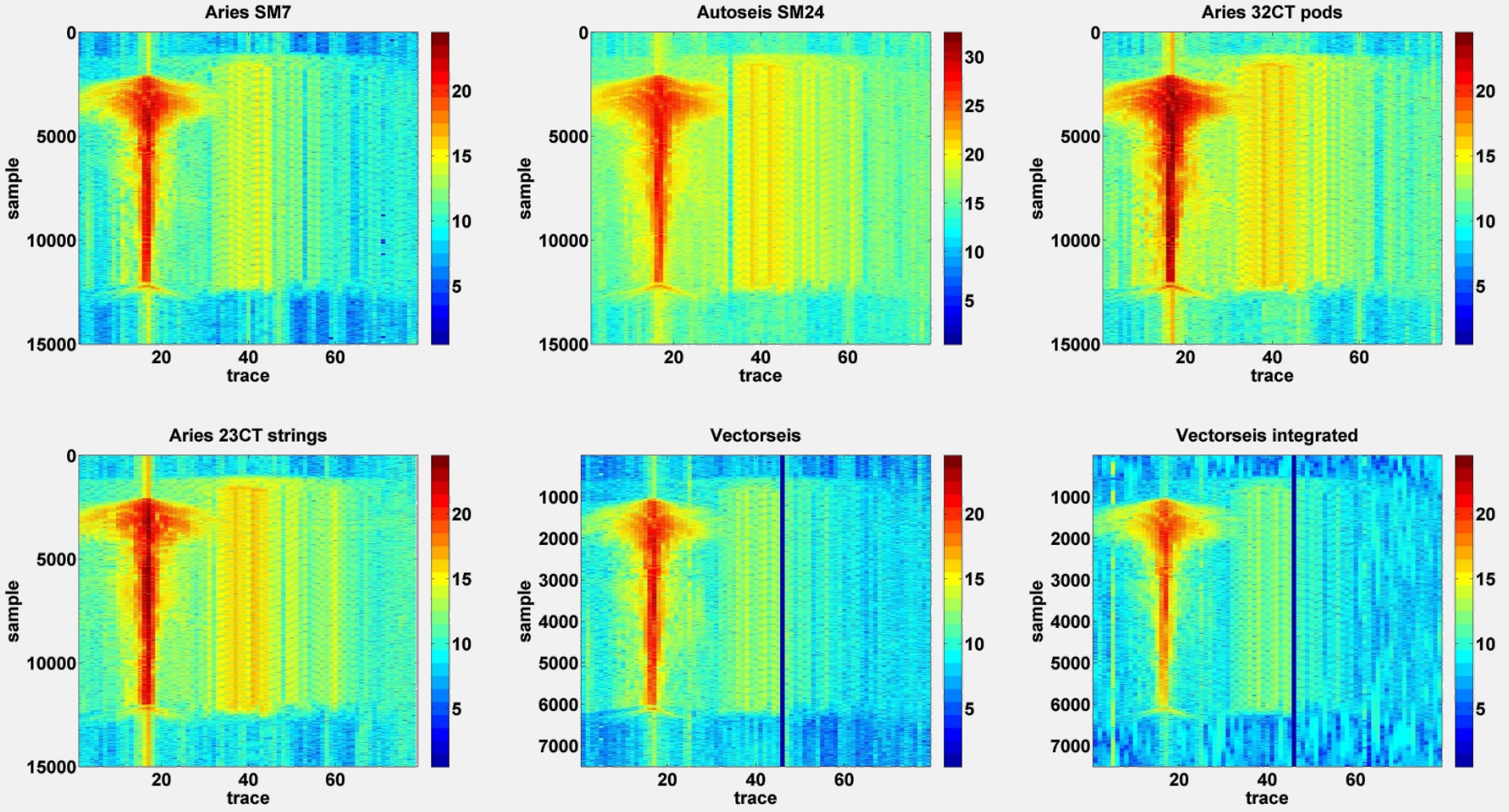
Courtesy: Helen Isaac

Vibrator gathers for Dual vibe

Vibe point 16179. Dual vibe. M22 stationary.



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Conclusions on this part

- The Autoseis system performs as well as the Aries system for this field work. There is no obvious benefit to either system from the point of view of data quality, except for traces within 40 m of the shot.

- This survey was not adequate to fully evaluate any advantages of the extra resolution of the Autoseis. Any benefits of a 32-bit recording system may become more apparent after high-fold stacking.

- The Autoseis is a ‘blind’ shooting system – there is no data transfer, QC or status information available at the recorder during acquisition.

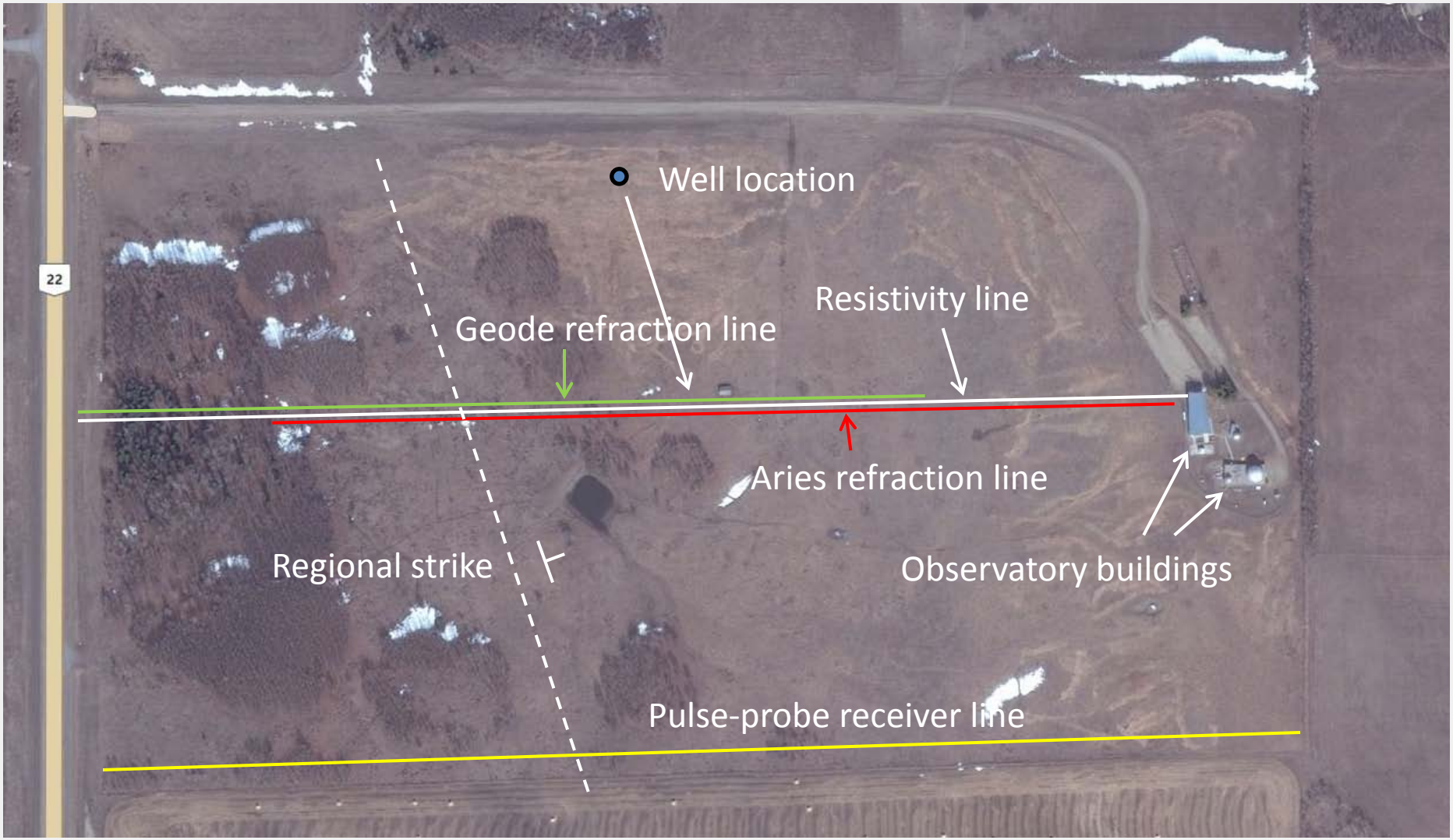
- The low frequency recovery is dependent on the sensor, rather than the recording system. The Autoseis and the Aries are similar in very low frequency response.

- The bit-level plot can be useful as a diagnostic tool for data analysis.

Future work

- Statistical analysis of the geophone coupling / planting comparisons

Priddis near surface survey



Resistivity:	Geode Refraction:	Aries refraction:
72 channel	72 channels @ 2.5 m	120 channels @ 5 m
Electrode spacing 10 and 5 m	Hammer source @ 15 m	Vibe points @ 10 m
Type: Dipole-dipole	4 layouts along line	Sweep 10-200 over 20 sec

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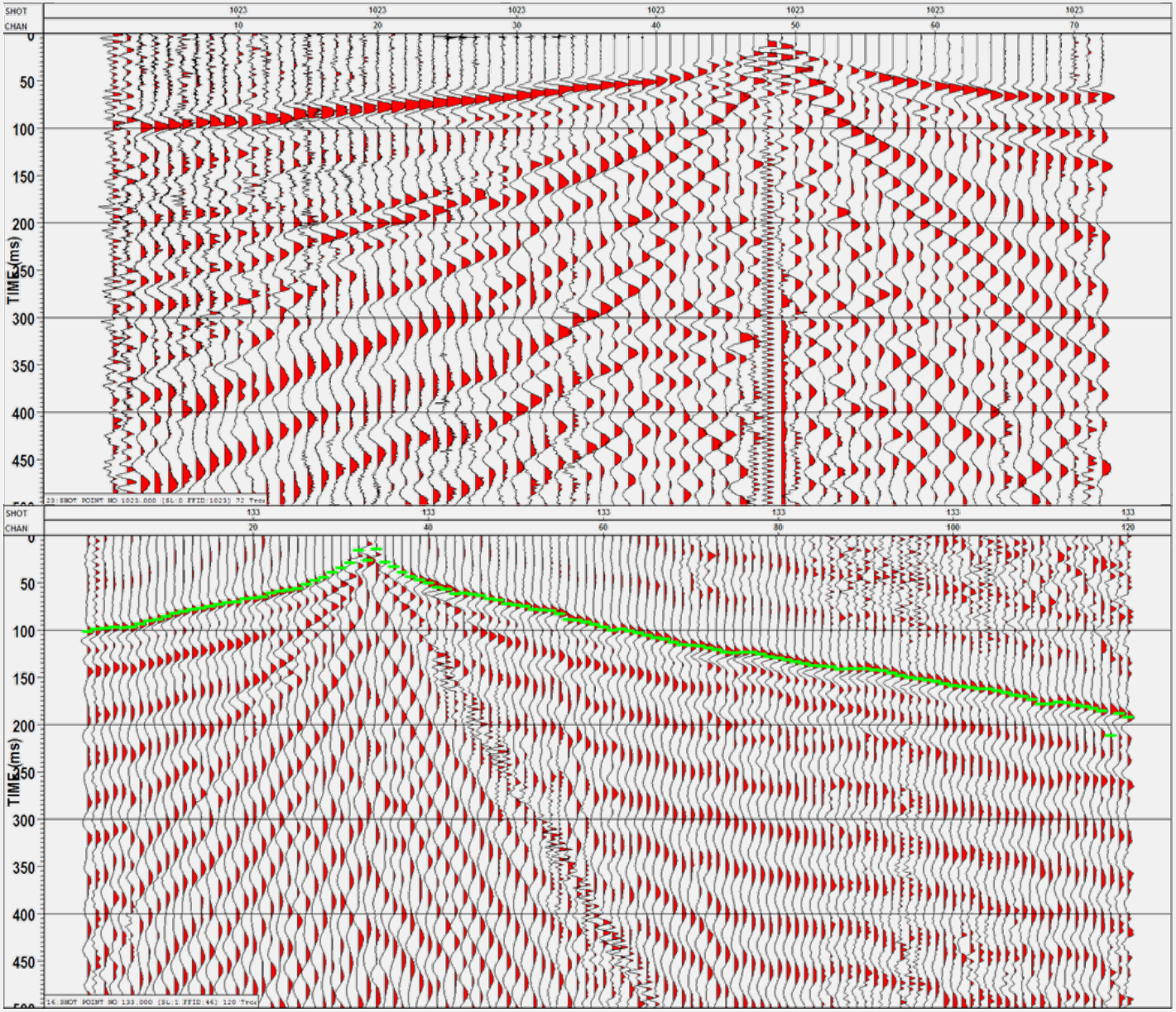
The refraction survey

Geode
72 channels
Hammer /plate
4 stacks



Aries
120 channels
Envirovibe
Sweep 10-200 Hz
2 stacks

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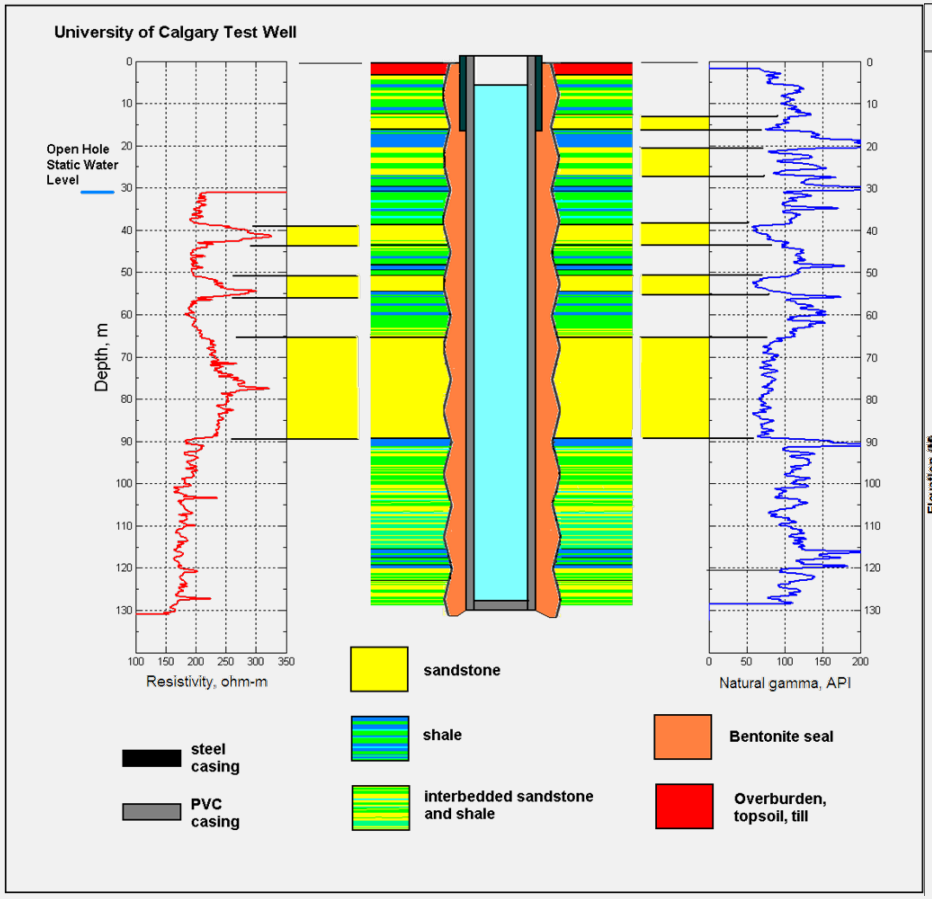
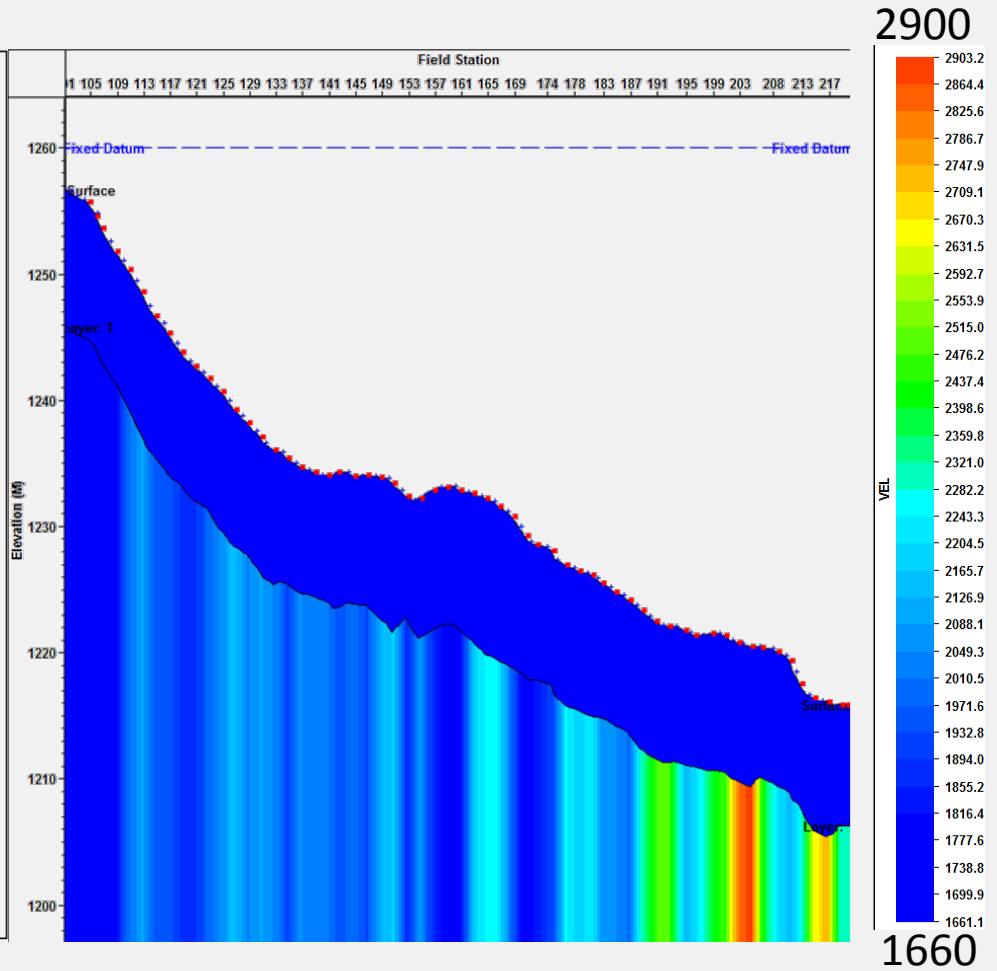
Well log and refraction velocity profile



Well log data



Vista velocity model

From: VSP and well logs from the U of C test well, Wong et al. , CREWES Research Report, 19

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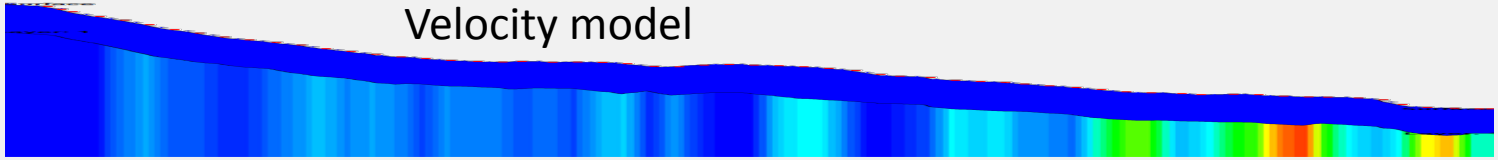
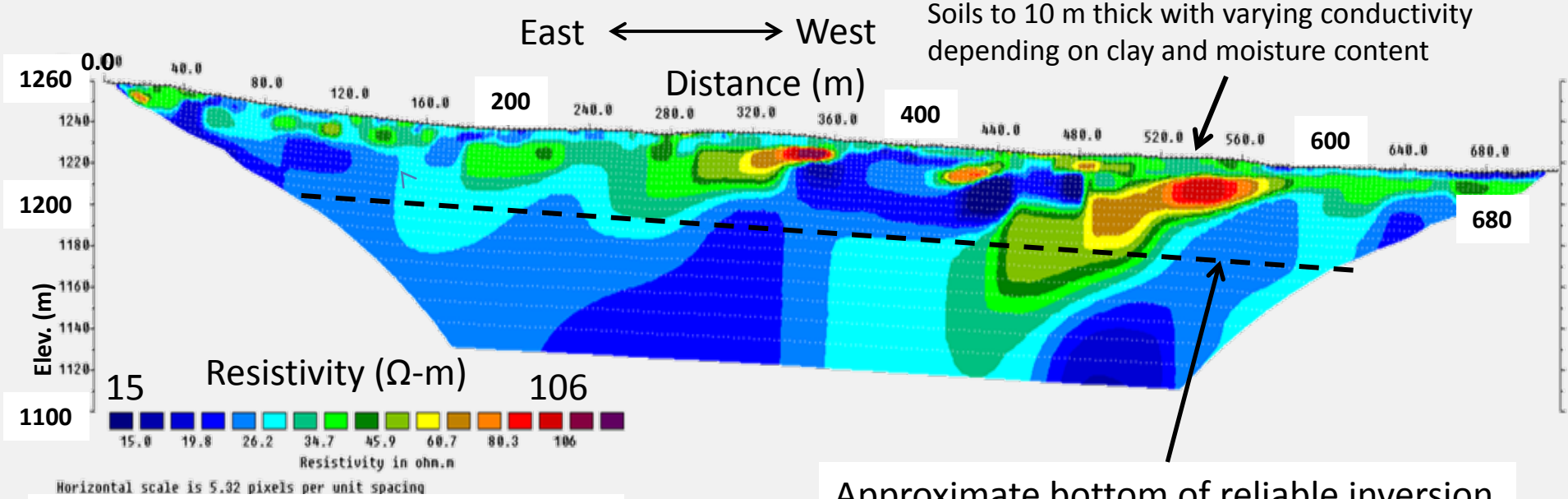
ERT Inversion
Combined 5 m and 10 m a-spacing





Sandstone > 70 Ω-m

30 Ω-m < Muddy sandstone < 70 Ω-m

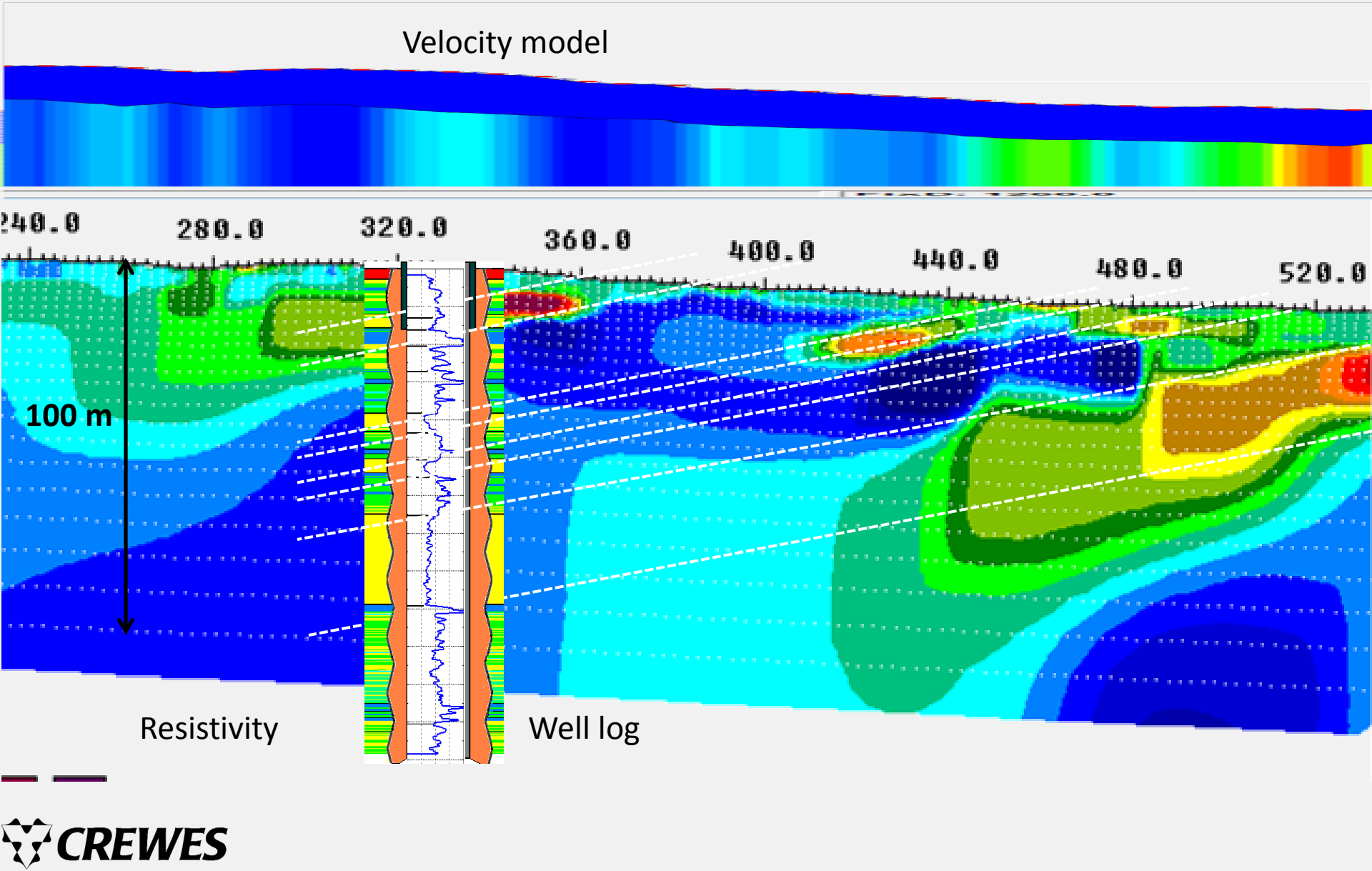
Mudstone < 30 Ω-m

5 Iterations; RMS Error 2.7%

Inversion from:
Larry Bentley and Lei Zhi
Hydrogeology

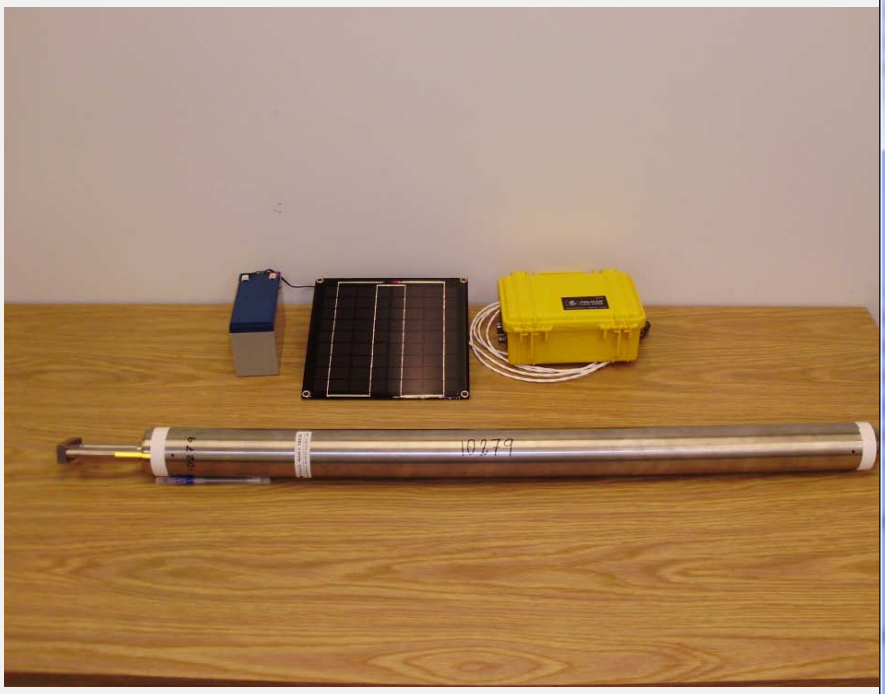
CREWES

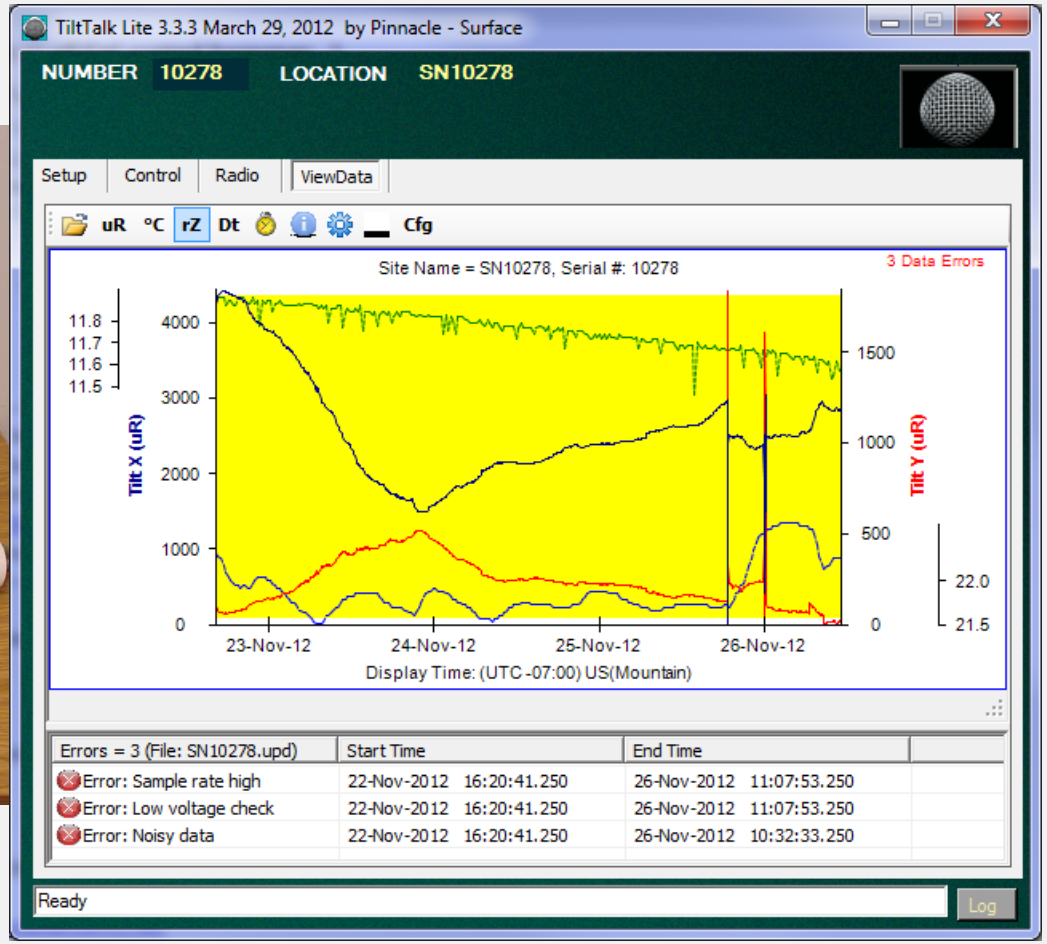
Putting it all together



CREWES

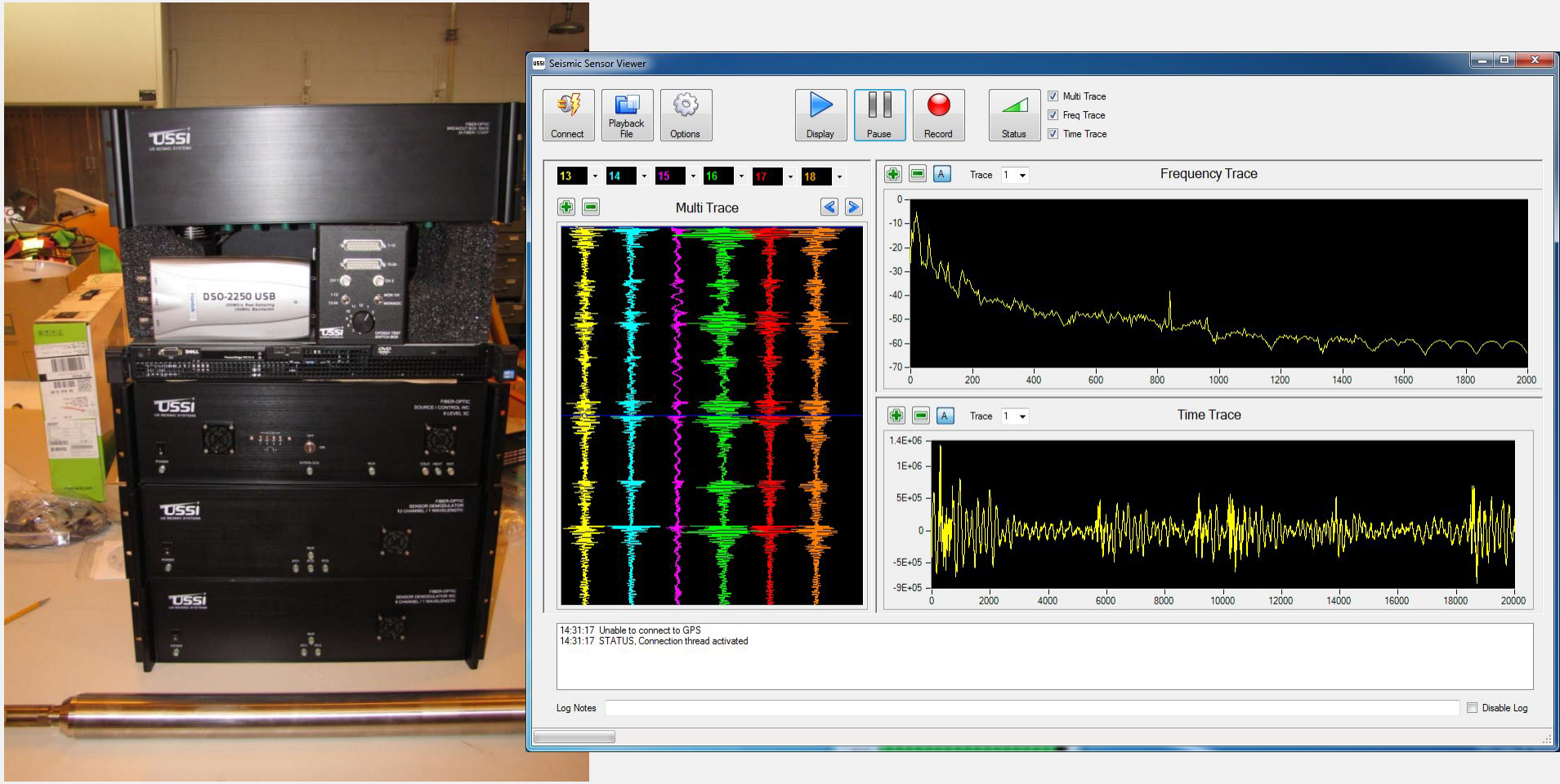
Tiltmeters





Manufactured by Pinnacle (Haliburton)

Optical accelerometers



Manufactured by US Seismic Systems Inc

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Shear wave thumper

Manufactured by United Service Alliance, Inc.

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- CREWES staff and students

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