Seismic data processing of georadar data

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CREWES

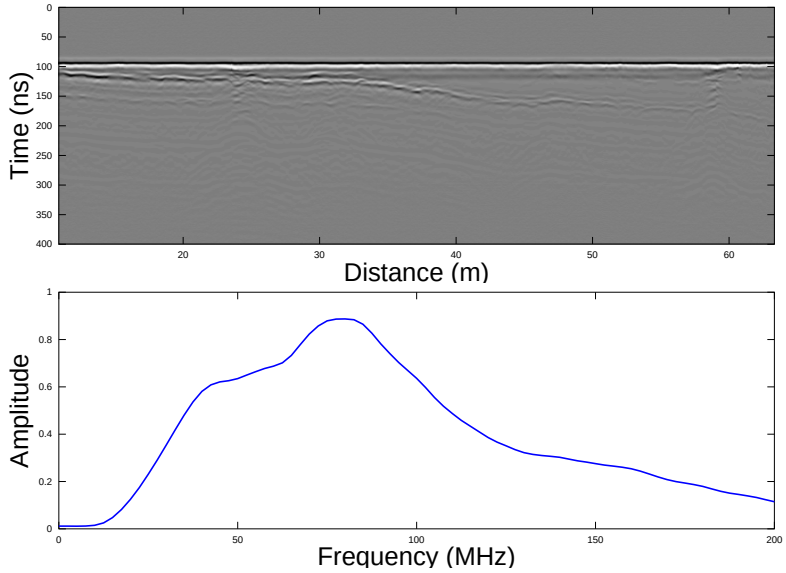
Summary

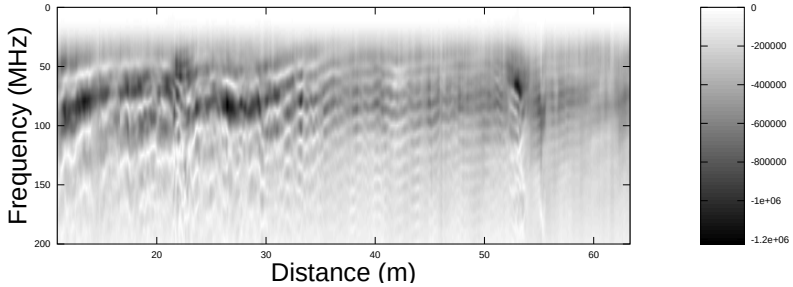
- Gabor nonstationary deconvolution plus PSDM improves bi-static georadar data.
- Frequency domain, monostatic acquisition shows great promise.

Acquisition

Parameter	Value
Number of radargrams	629
Δx	$\sim$ 10 cm
Source - receiver offset	1 m
Expected velocity	0.053 m/ns (5.3 $\times 10^7$ m/s)
f_{dom}	100 MHz
λ_{dom}	0.53 m
Δz_{Ricker}	0.11 m

Signal analysis

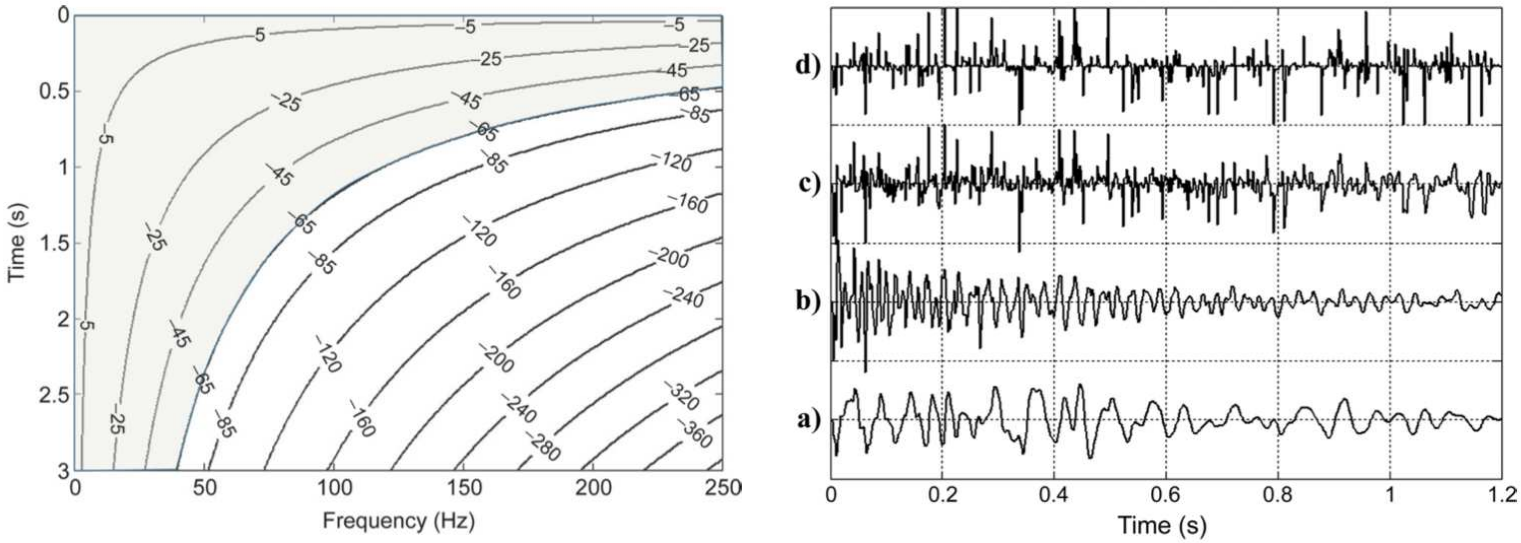




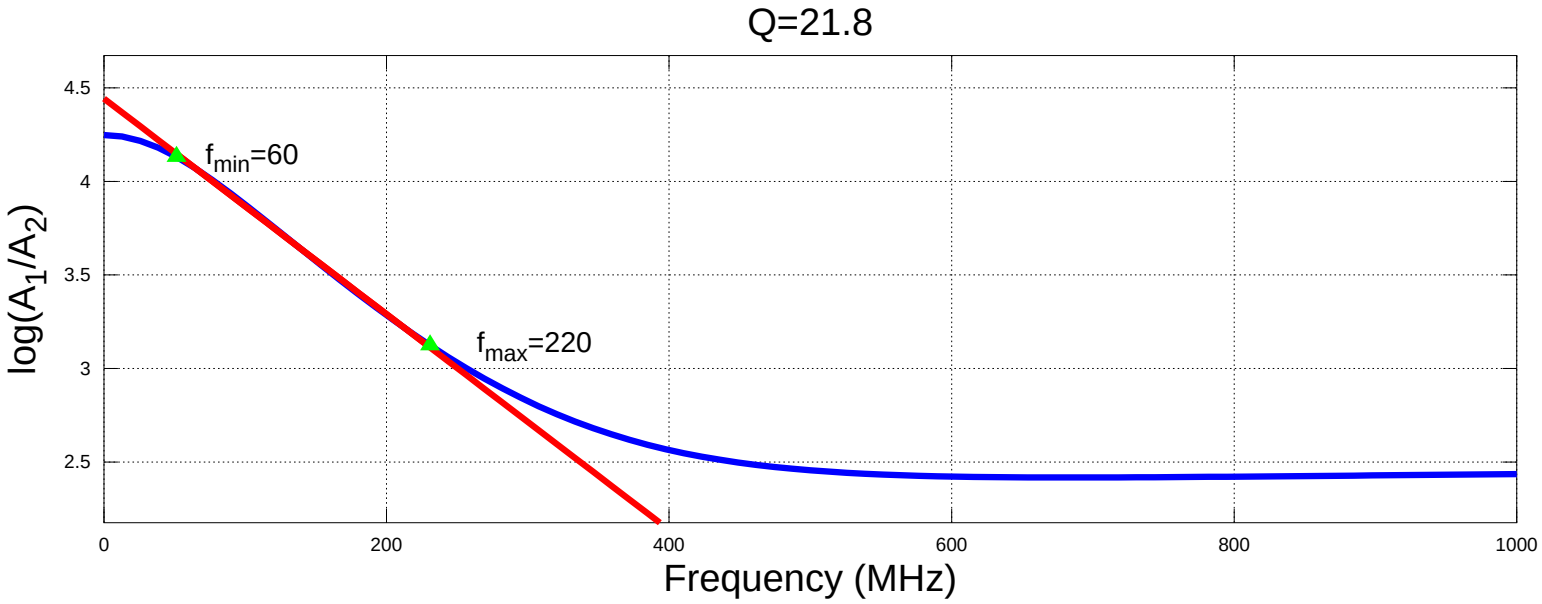
The bandwidth of the **raw data** is 20 - 200 MHz, and $f_{dom} \sim 75$ MHz.

Signal processing

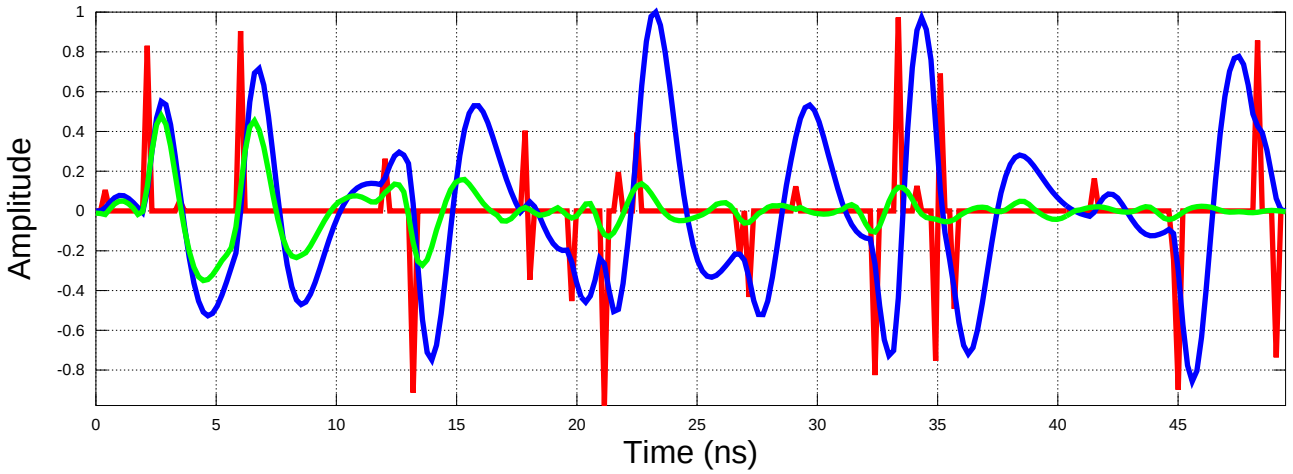
- Radar is strongly attenuated (Q) in earth materials.
  - Conventional processing does not correct Q.
- Gabor deconvolution (Margrave et al., 2011) compensates for Q.
  - Q compensation significantly improves georadar reflections.



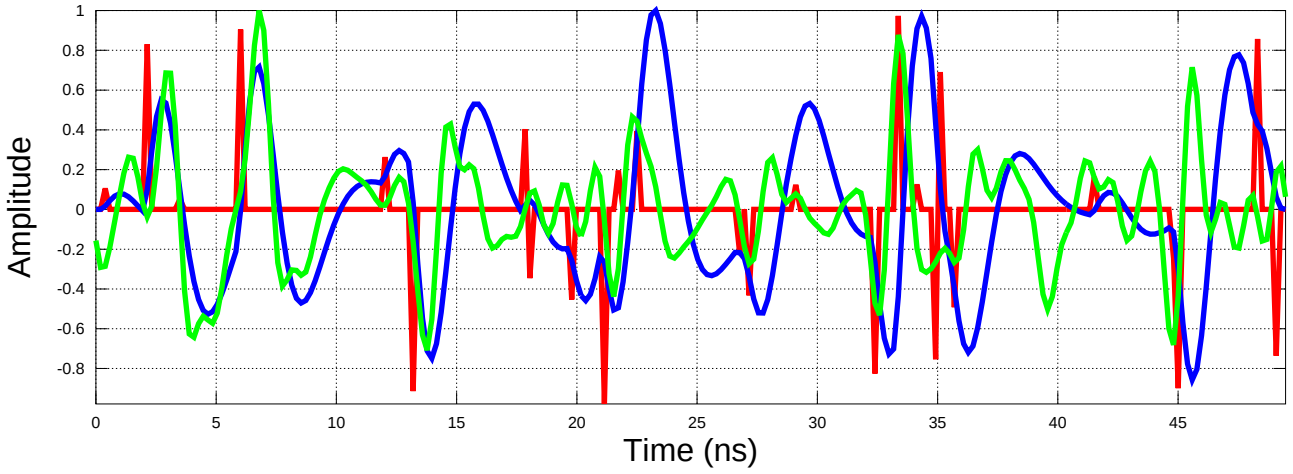
Q varies in time and frequency (left side above) (from Margrave et al., 2011). Georadargram (a, right side) is low resolution compared with the ideal (d). Gabor deconvolution (c) is superior to conventional deconvolution (b).



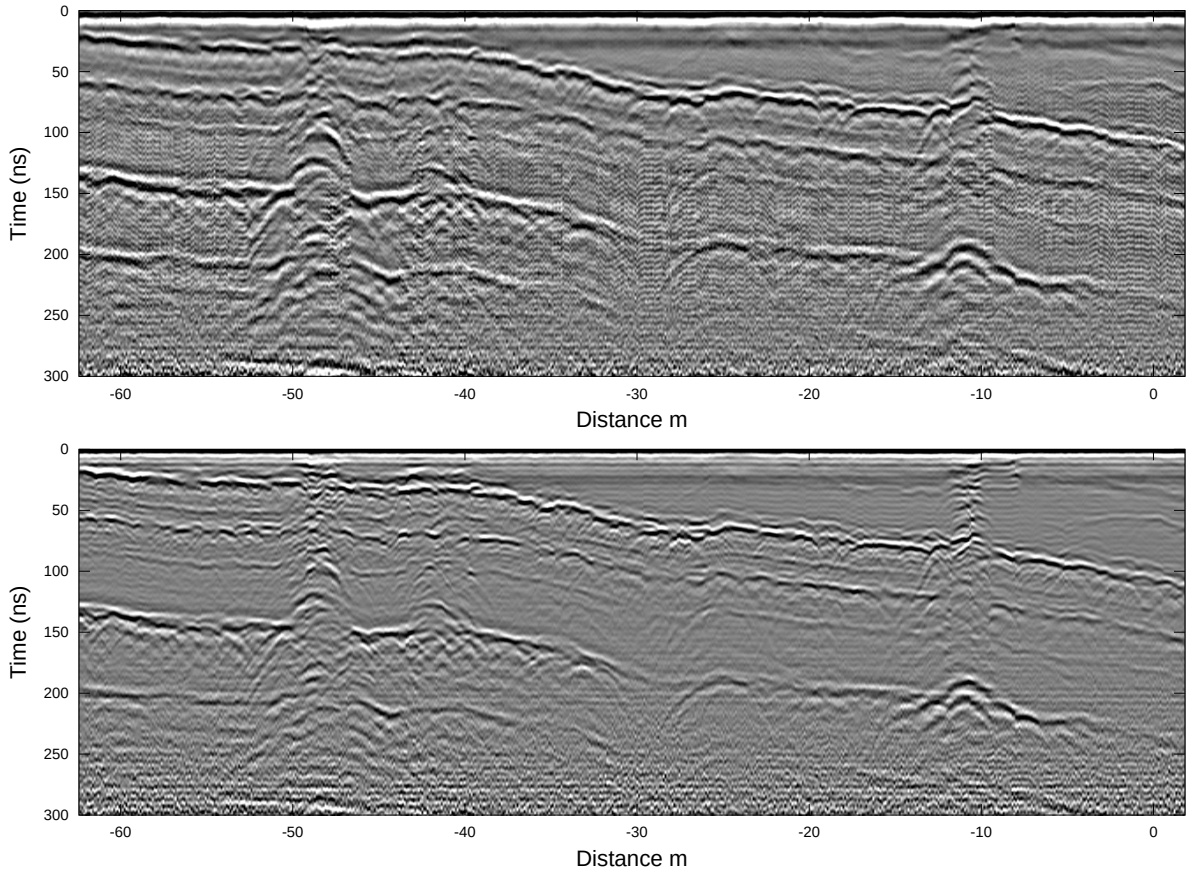
Q estimation by the spectral-ratio method.


Amplitude
Time (ns)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
5
10
15
20
25
30
35
40
45

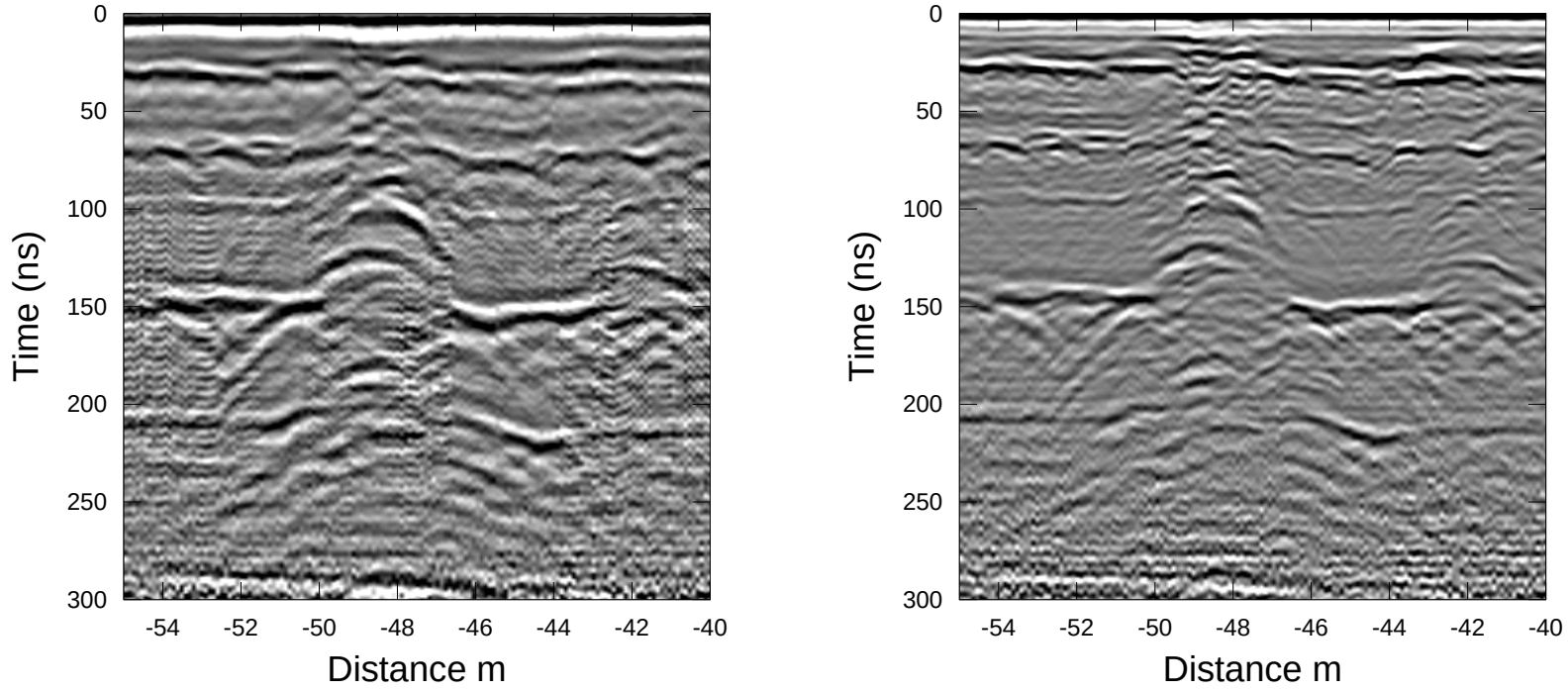
(a)


Amplitude
Time (ns)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
5
10
15
20
25
30
35
40
45

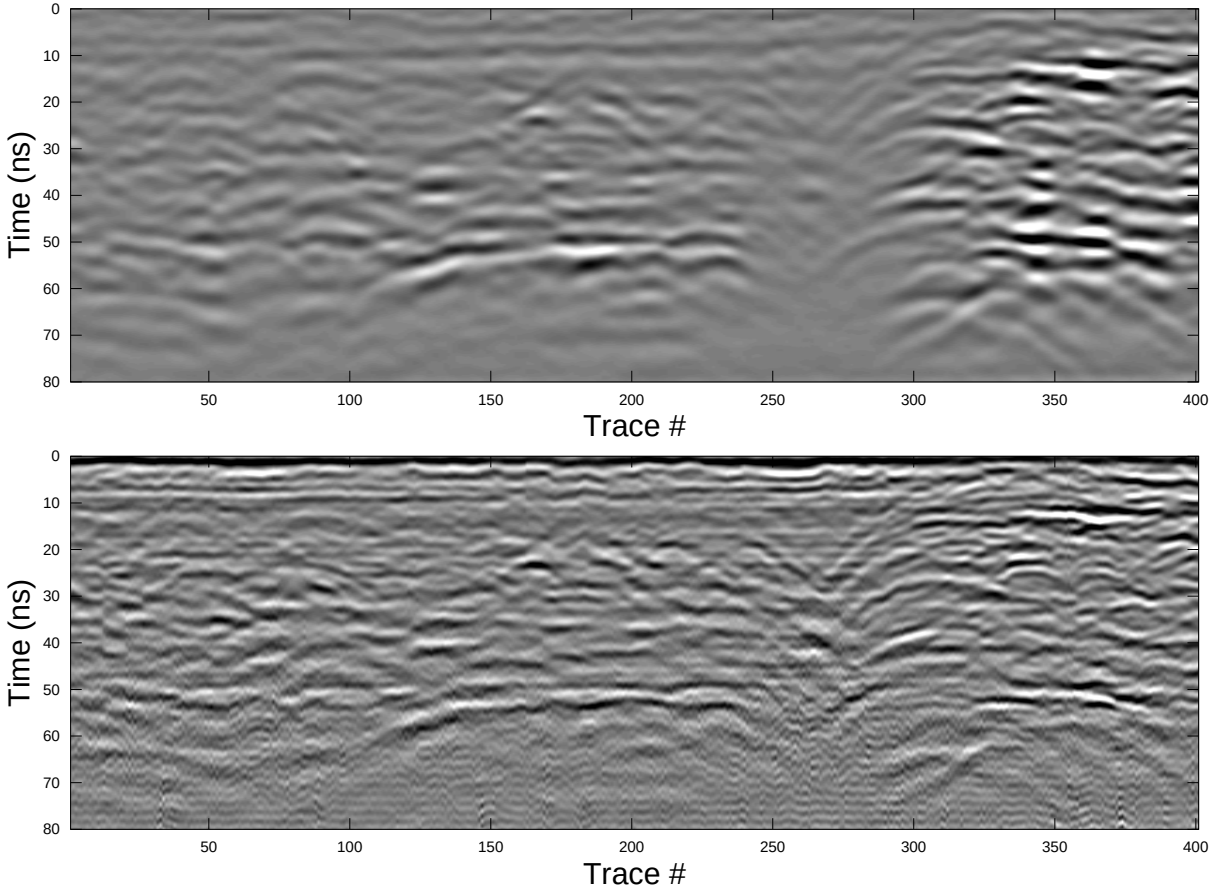
(b)



From a quarry in Denmark. Conventional deconvolution (top) improves our raw data. Gabor deconvolution (bottom) is even better.

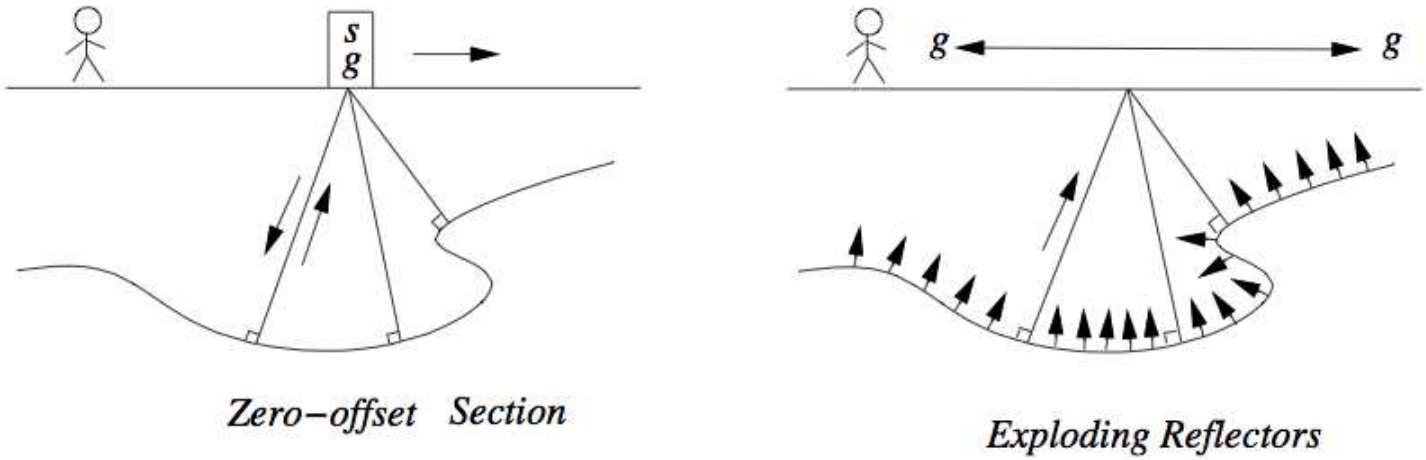


A Utah basalt. Conventional deconvolution (left). Gabor deconvolution (right).

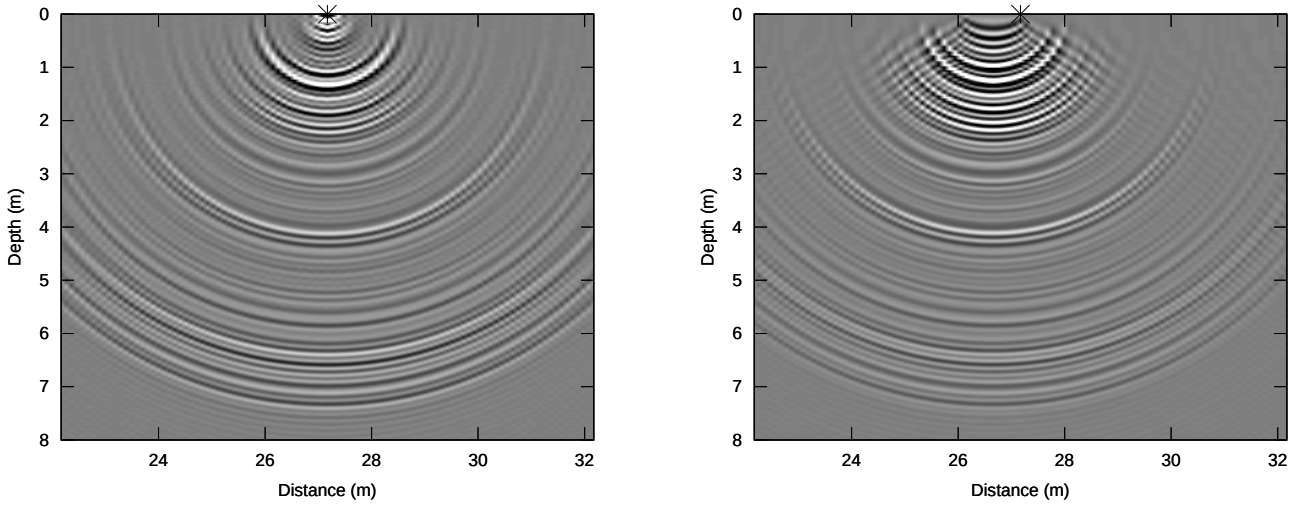


An earthquake fault in Italy. Conventional processing (top). Gabor deconvolution (bottom).

Imaging

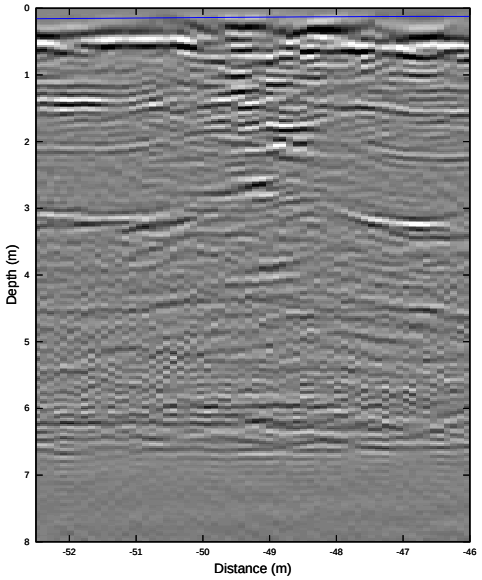


The *Exploding reflector model* for zero-offset migration (ZOM) (Claerbout, J. F., 1984). The antennae are assumed to be co-located.

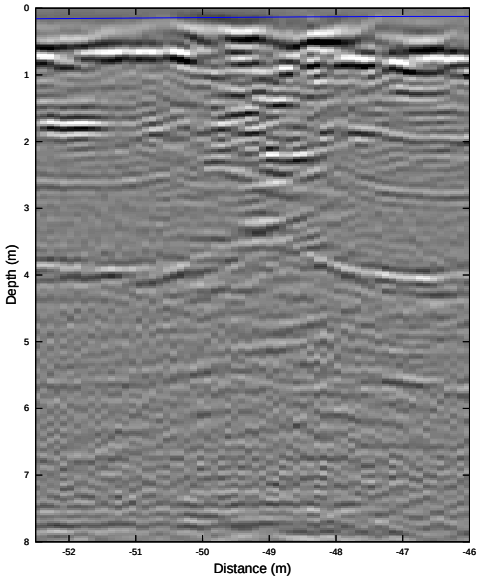


Antennae are not coincident (1 m separation is typical) so ZOM (left side) is wrong in the shallow section. Prestack depth migration (PSDM, right side) is correct.

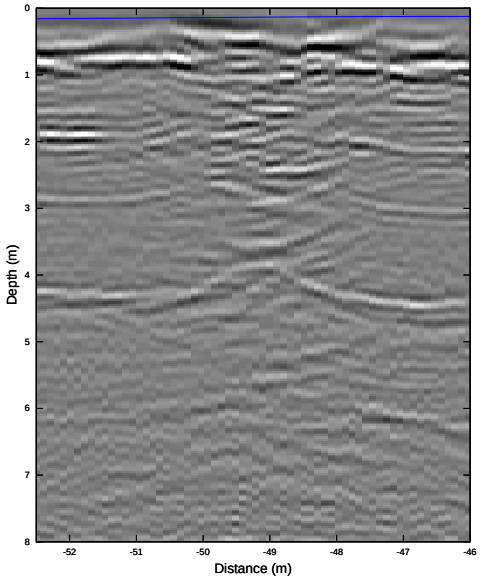
Velocity analysis



(c) $\alpha = 0.7$



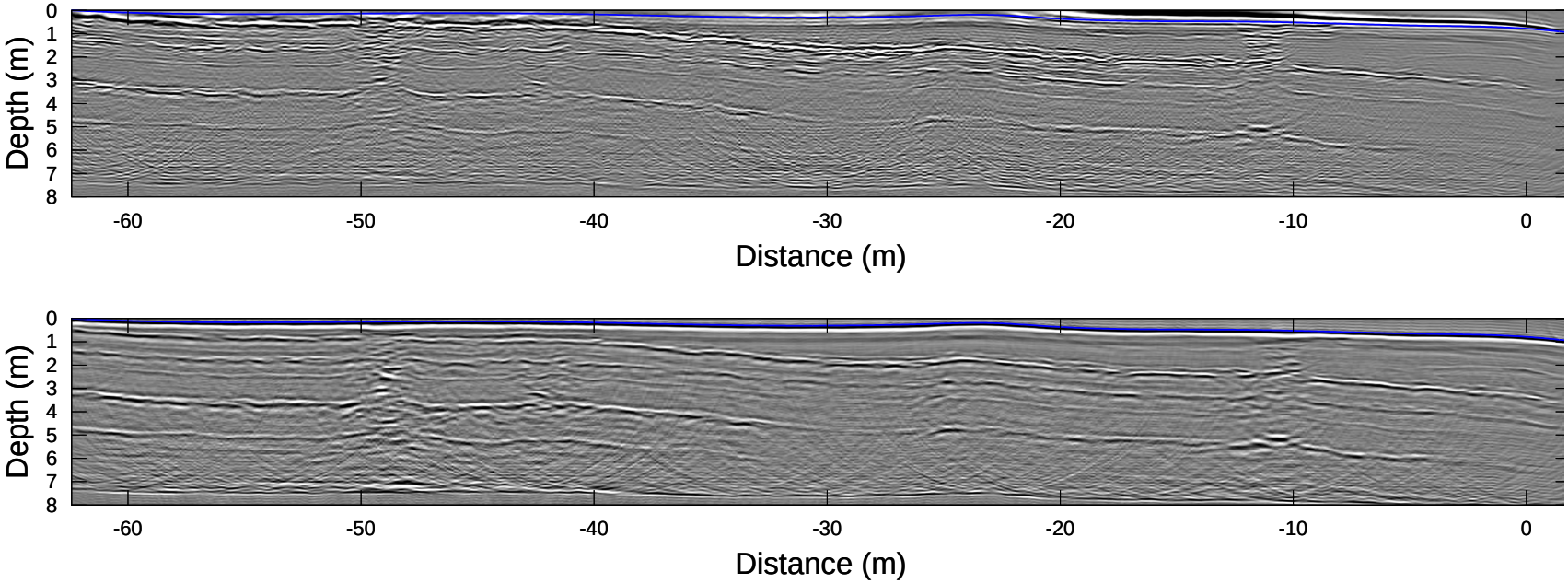
(d) $\alpha = 0.9$



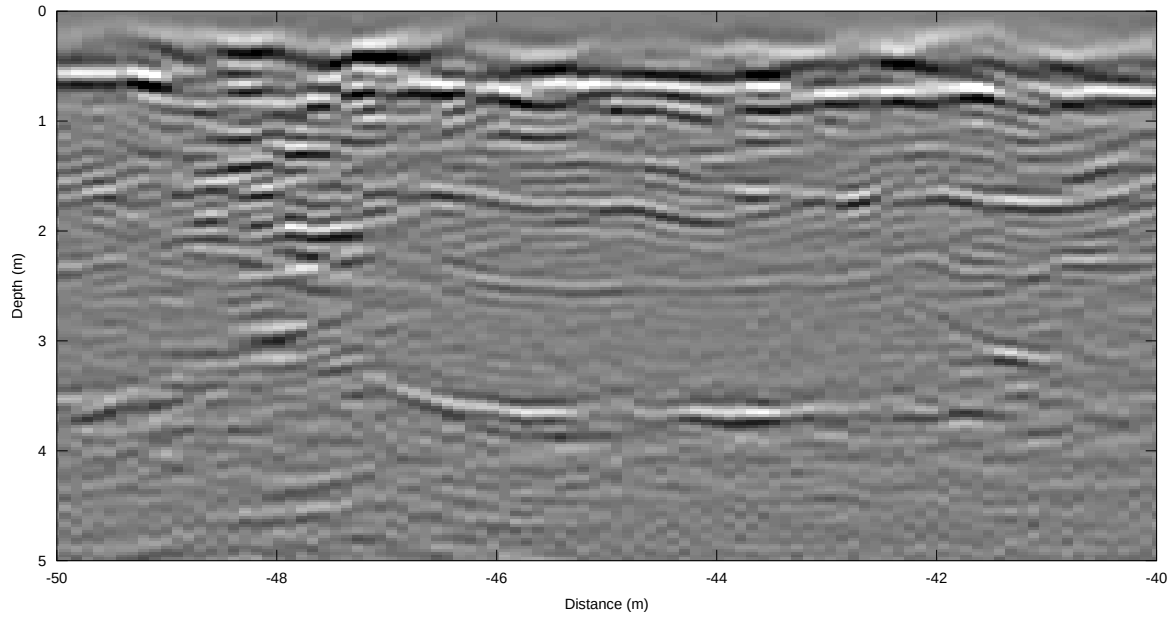
(e) $\alpha = 1.1$

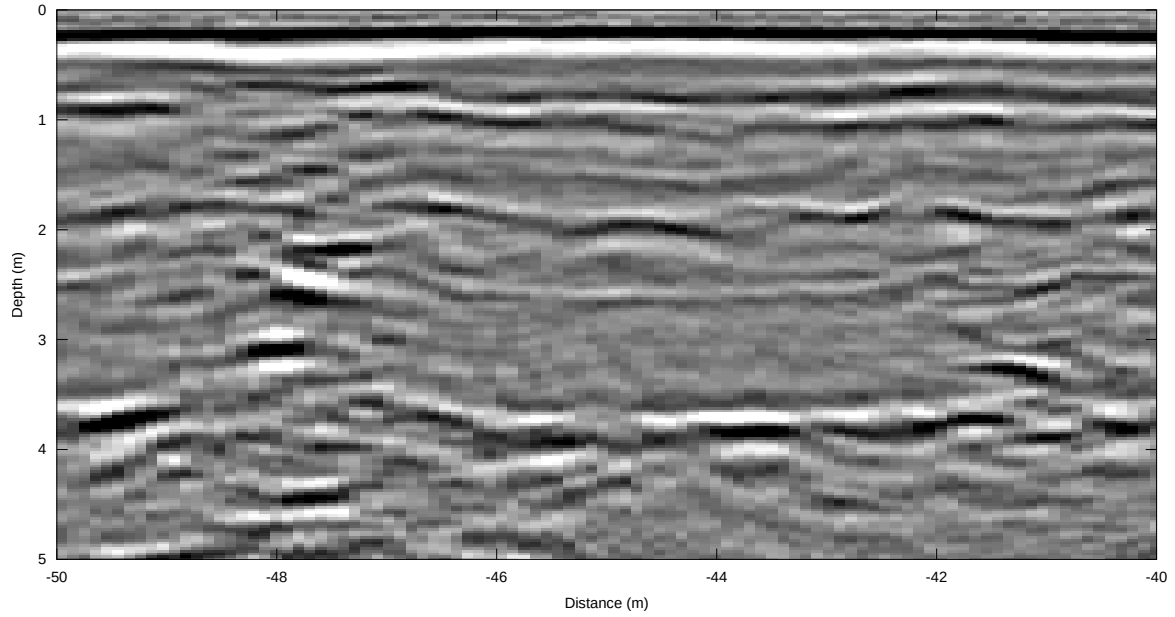
Vary α until good focusing is achieved.

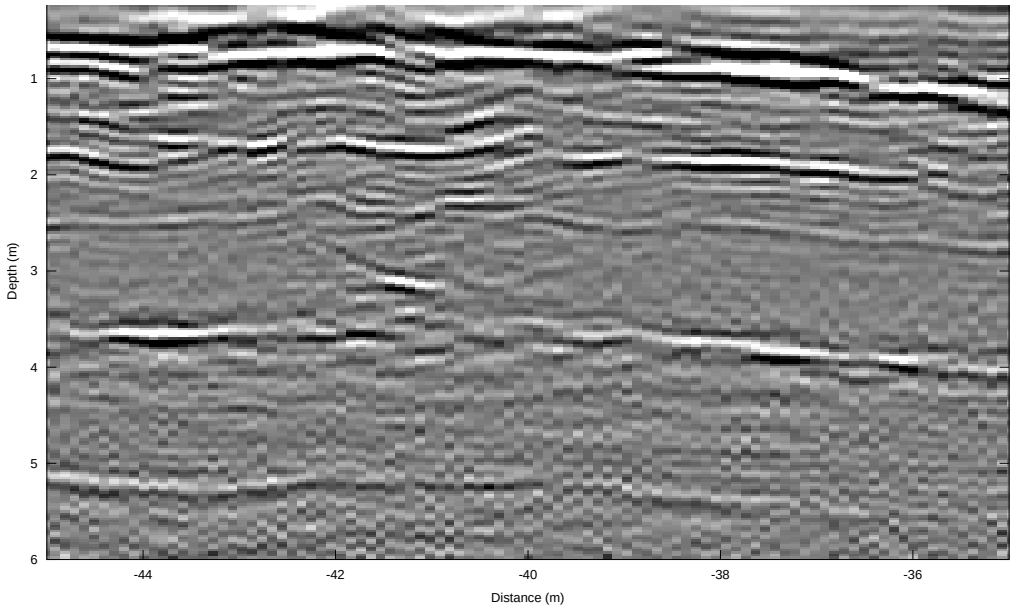
Final images

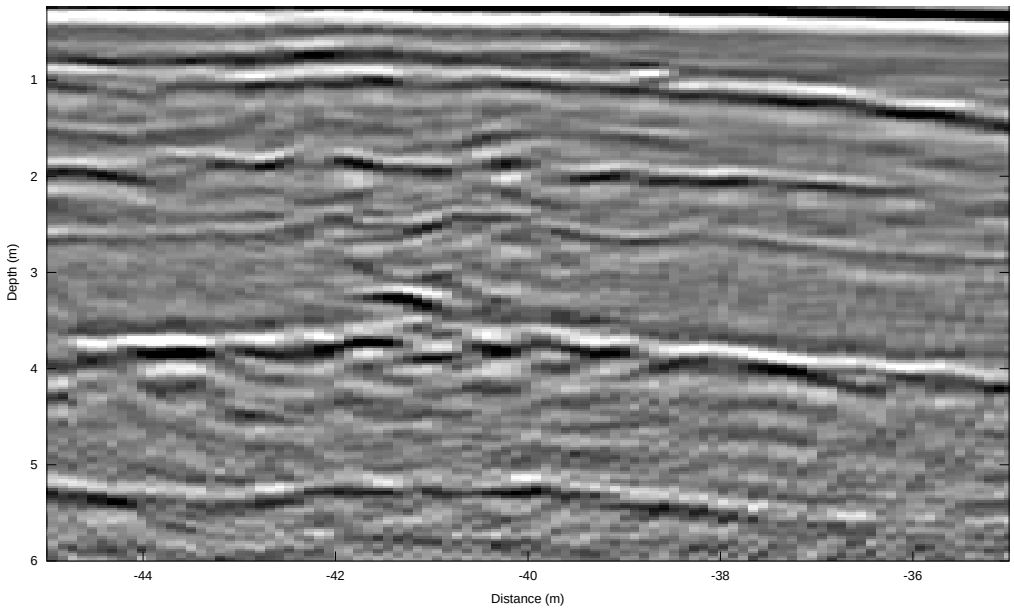


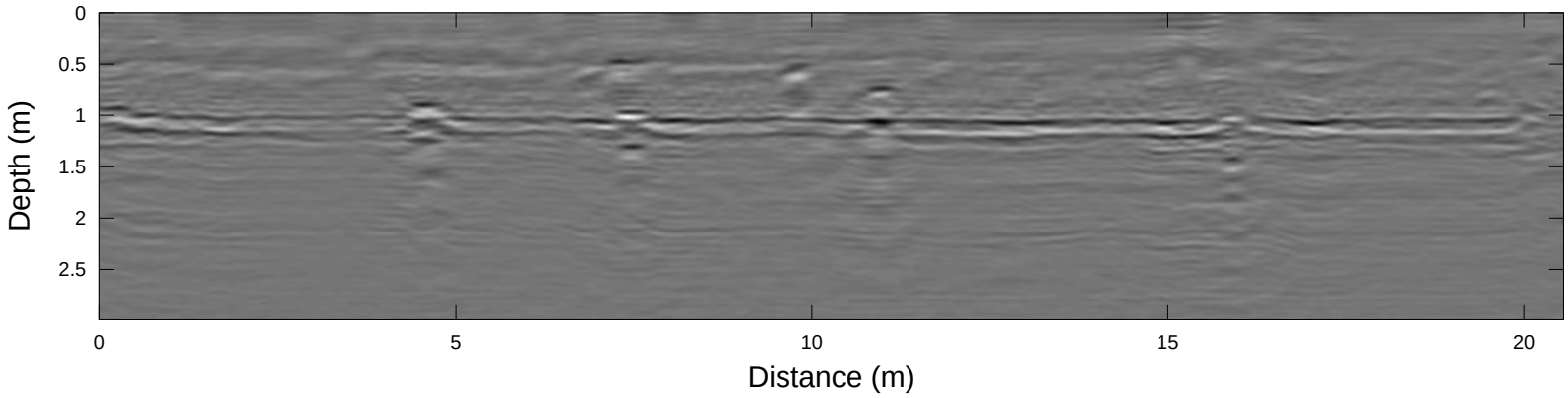
Quarry. Gabor decon + PSDM (top) verses Gabor and ZOM.

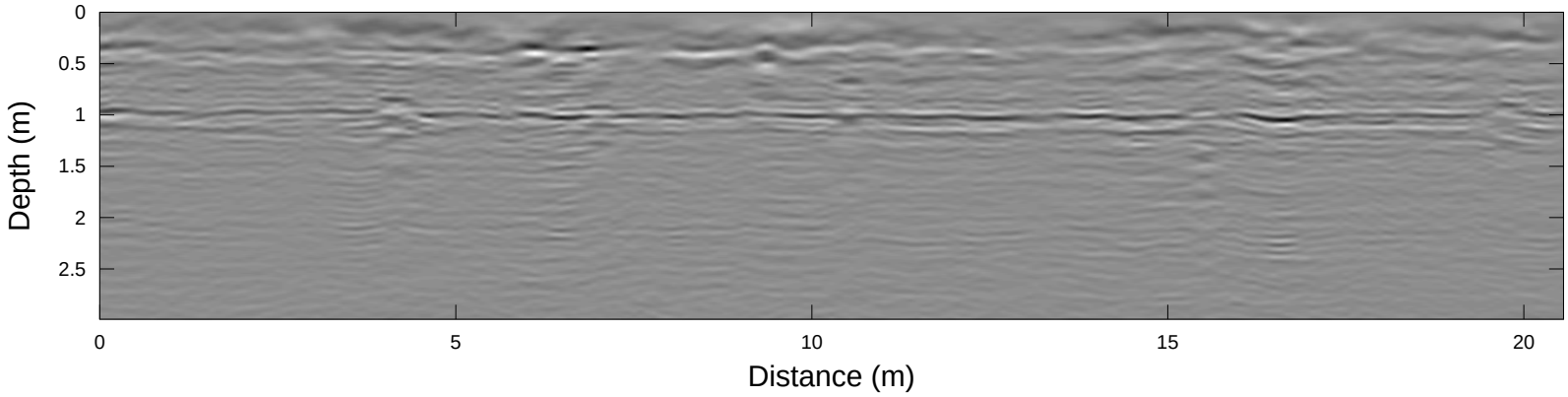

0
1
2
3
4
5
Depth (m)
-50
-48
-46
-44
-42
-40
Distance (m)

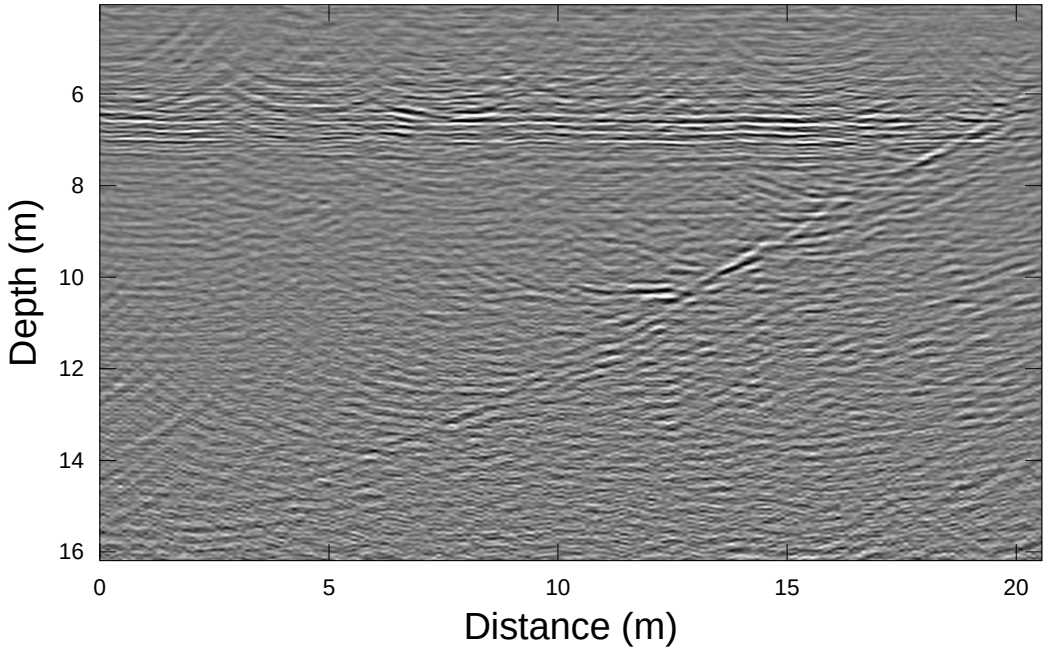

0
1
2
3
4
5
Depth (m)
-50
-48
-46
-44
-42
-40
Distance (m)

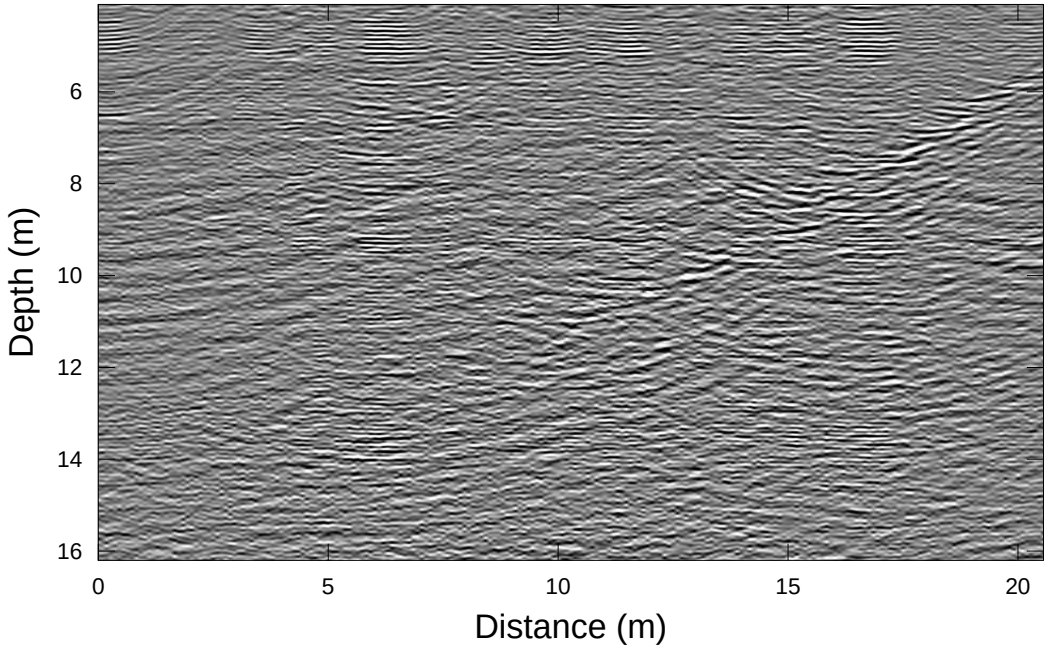

Depth (m)
1
2
3
4
5
6
-44
-42
-40
-38
-36
Distance (m)

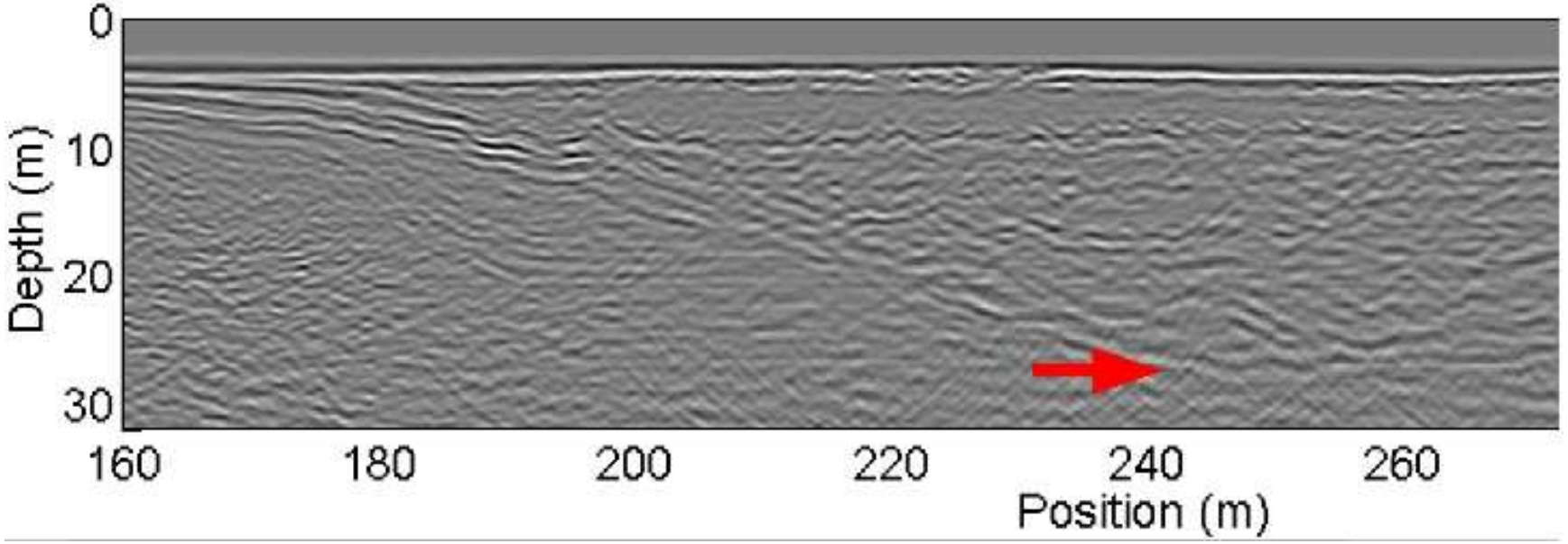

Depth (m)
1
2
3
4
5
6
-44
-42
-40
-38
-36
Distance (m)


Depth (m)
0
0.5
1
1.5
2
2.5
0
5
10
15
20
Distance (m)


Depth (m)
0
0.5
1
1.5
2
2.5
0
5
10
15
20
Distance (m)


Depth (m)
6
8
10
12
14
16
0
5
10
15
20
Distance (m)


Depth (m)
6
8
10
12
14
16
0
5
10
15
20
Distance (m)



Utah basalt.

Conclusions

- Gabor deconvolution and PSDM improve the radar image.
- Data is present at later times in the recording - longer recordings will capture deeper reflections.
- Dynamic range is a barrier.
- Monostatic recording shows great potential.

Acknowledgements

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