Computing pseudo-crosswell data by using seismic interferometry with sources on the surface

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Outline

Introduction: what is seismic interferometry?

Especial case: VSP in a crosswell configuration

Results: Aperture effect and fold distribution analysis

Conclusions and future work

Acknowledgments

Introduction

Seismic interferometry → Tool for computing pseudo-seismic data by cross correlating traces recorded at different receiver locations.

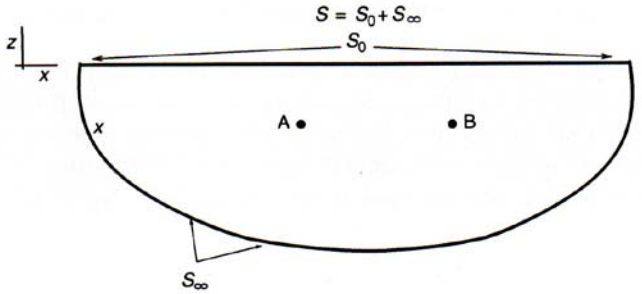
The cross correlation and summation of seismic traces produces virtual events with shorter raypaths and sources located closer to the target zone (Schuster, 2009).

Reciprocity Equation of the Correlation Type

After far field approximation in the frequency domain:

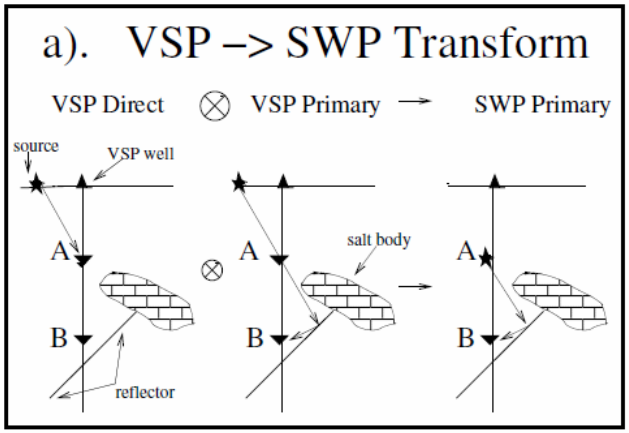
$$Im[G(B|A)] = k \int_S G(x|B)^* G(x|A) d^2x$$

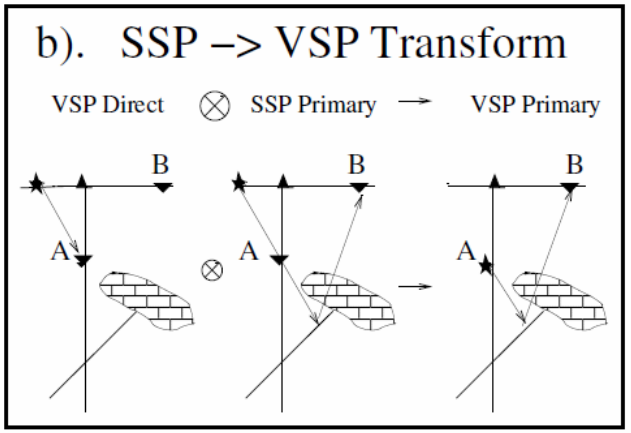
Wapenaar et al (2002)

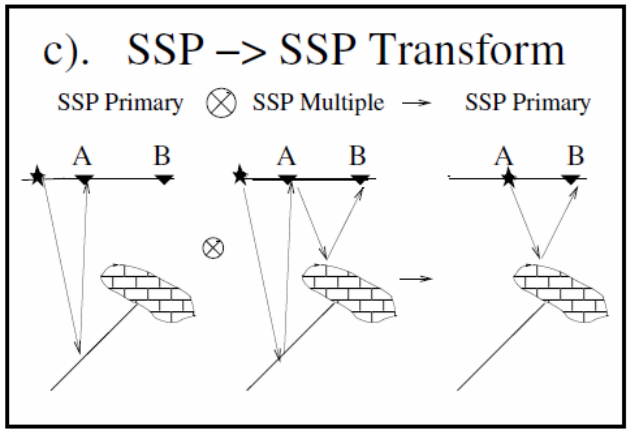


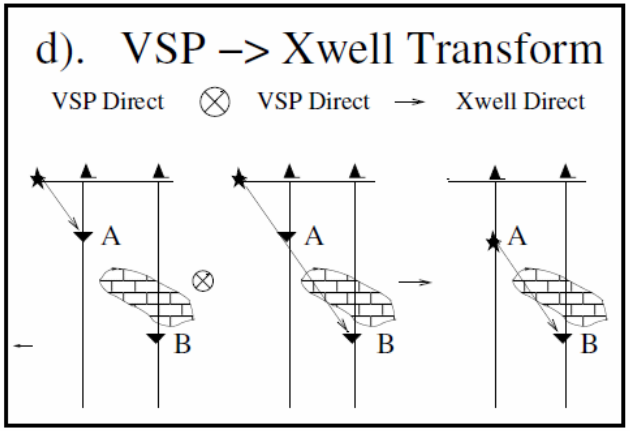
Introduction

Examples of different transforms of the data





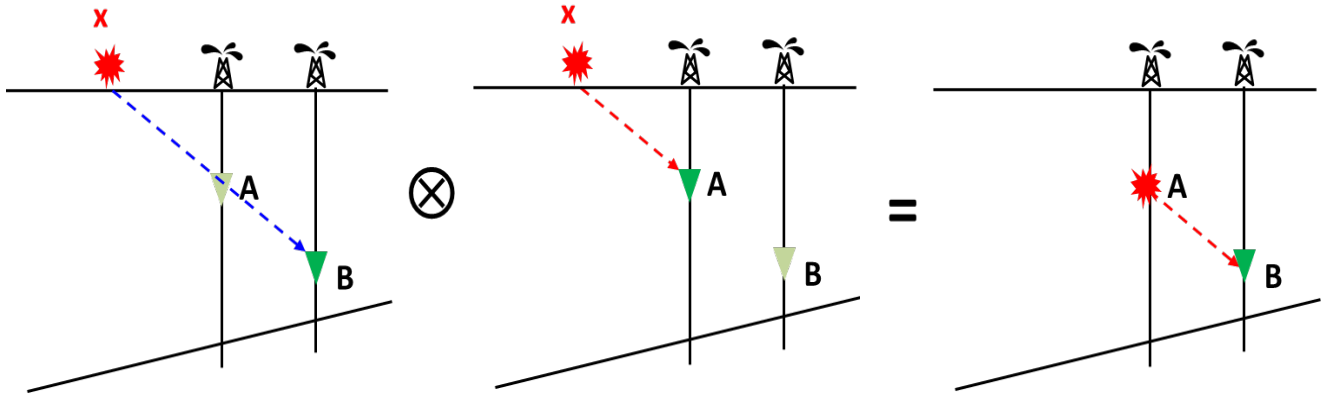




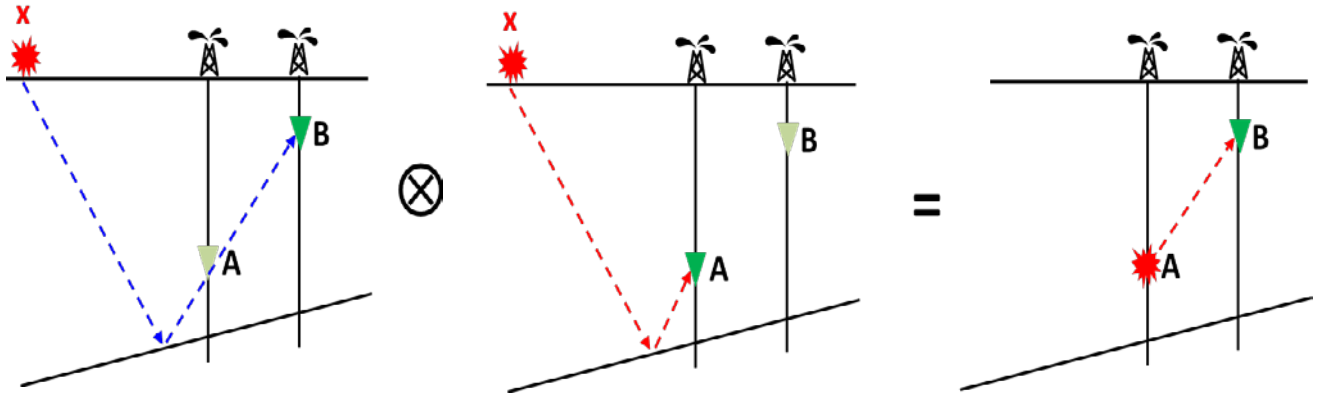
(Schuster, 2009)

Especial case: VSP-Xwell

The direct arrival



The reflected arrival

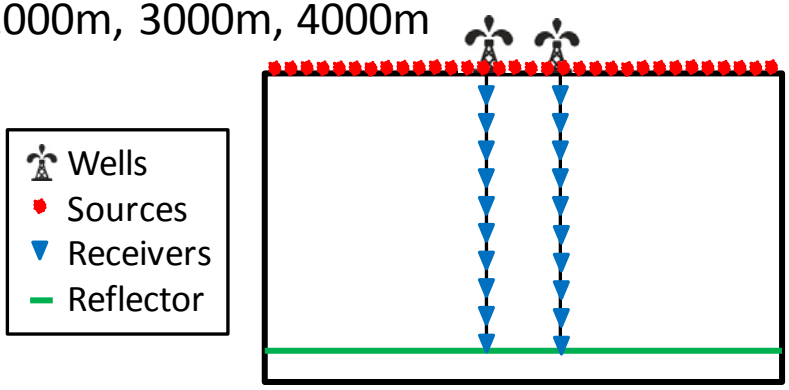


Result: a trace with shorter traveltimes as if the source were located at A and the receiver at B.

Especial case: VSP-Crosswell

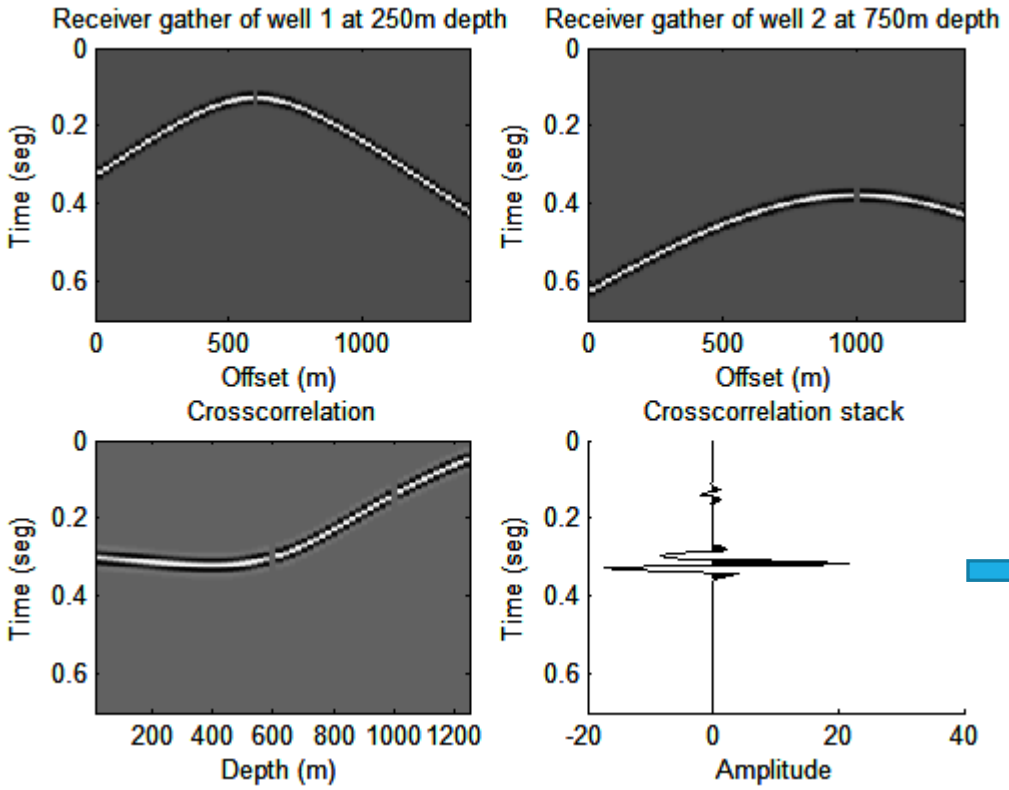
Parameters of the synthetic adquisition

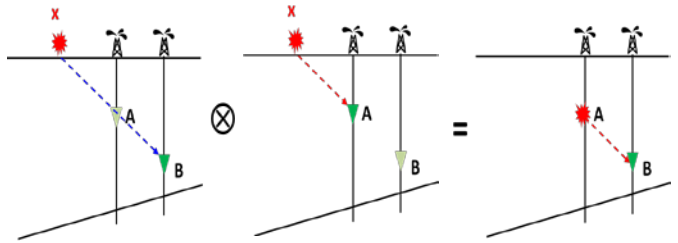
Model dimensions	8000m length, 1300m depth
Number of shots and spacing	401, 20m
Spacing between wells	400m
Number of receivers and spacing	120, 10m
Reflector depth	1250m
Maximum offsets	1000m, 2000m, 3000m, 4000m



Especial case: VSP-Crosswell

Interferometric computation of a pseudo-crosswell trace





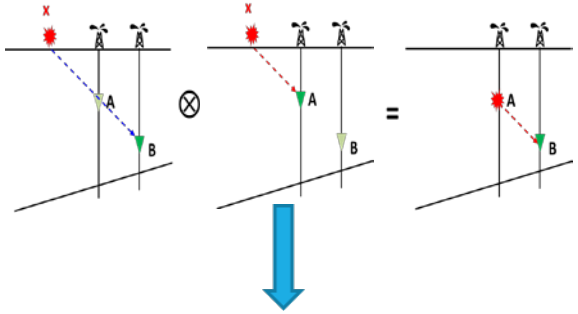
Seismic trace with a shorter traveltime corresponding to the traveltime between both receivers.

Results

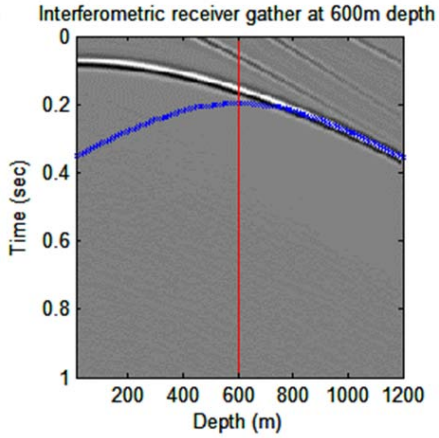
Aperture effect

- Receiver gathers at 100m, 600m and 1100m depth
- Ray traced traveltime in blue
- Reference depth of well 1 in red

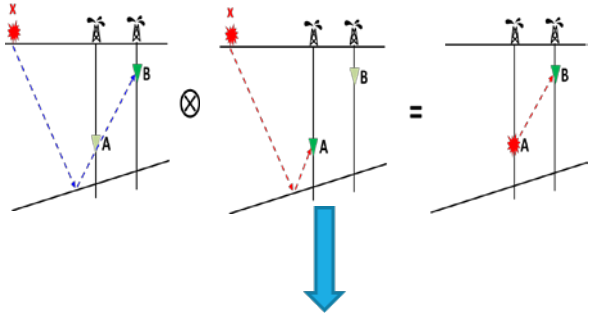
Downgoing waves



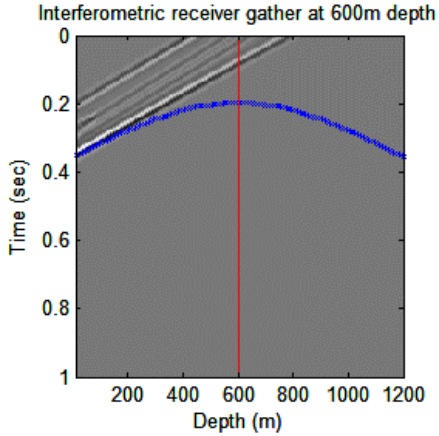
Right side of the red line



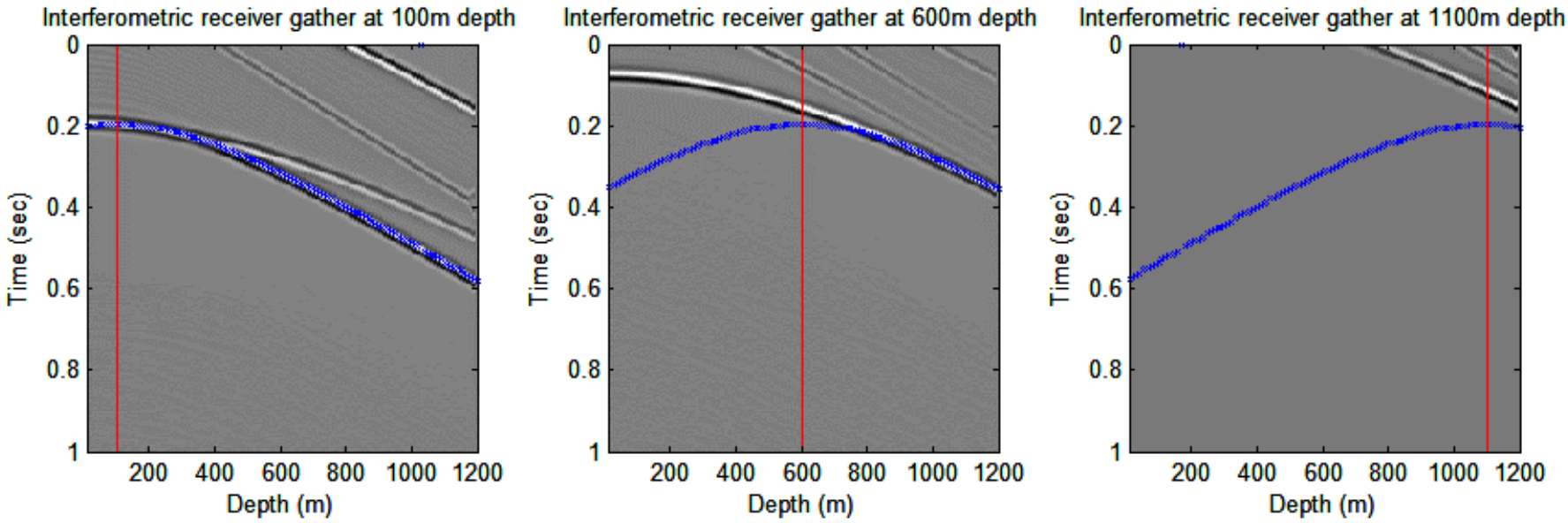
Upgoing waves



Left side of the red line

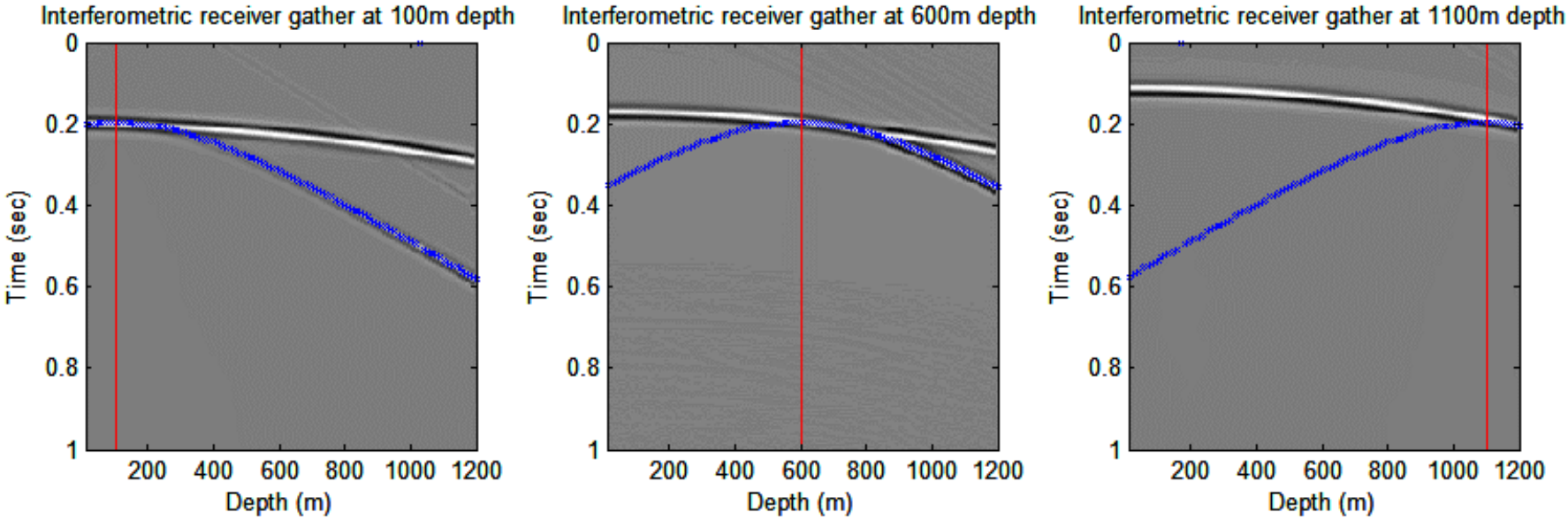


Aperture effect: direct P waves



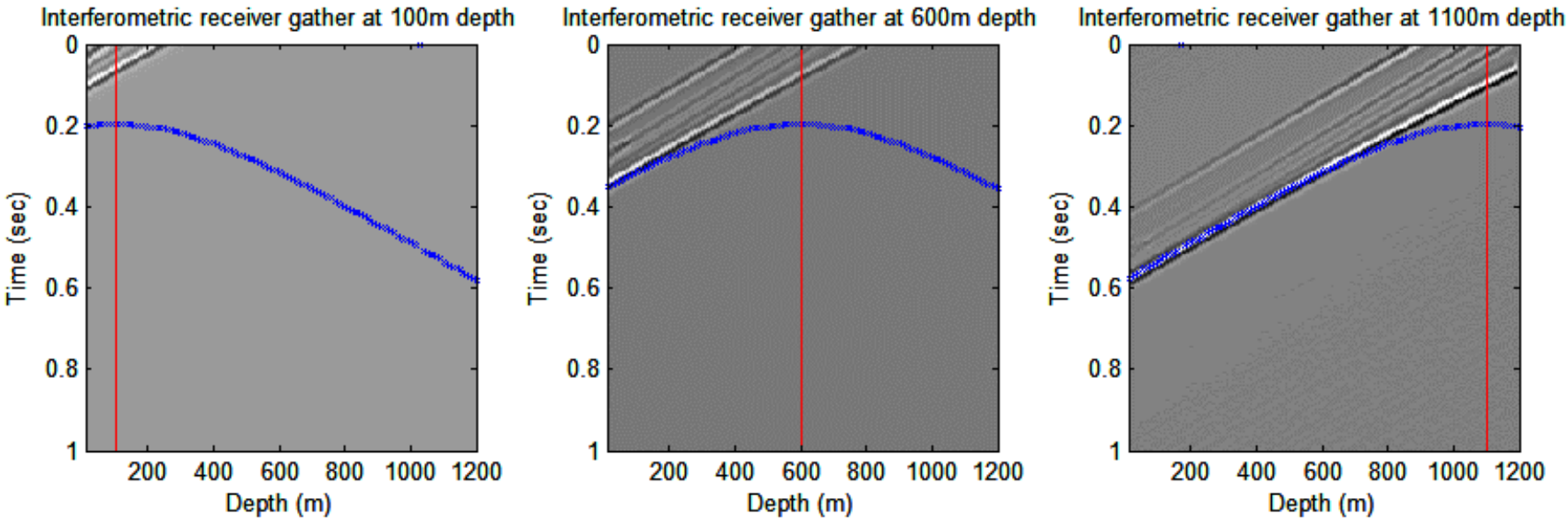
Max offset 1000m

Aperture effect: direct P waves



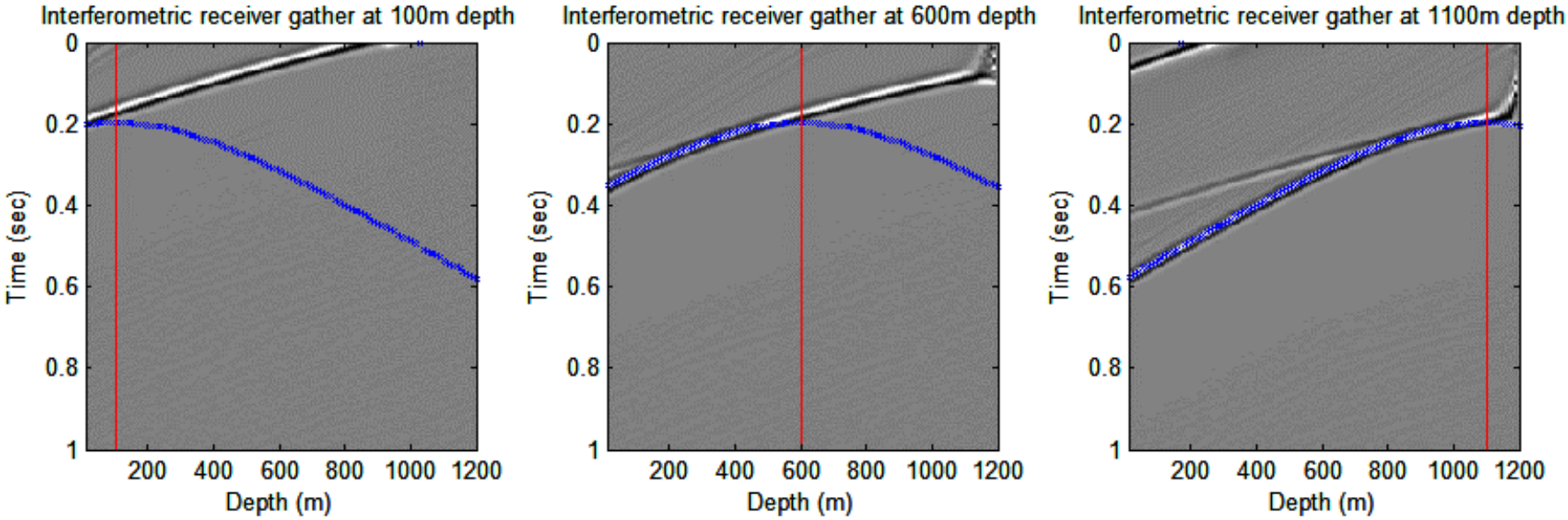
Max offset 4000m

Aperture effect: reflected P waves



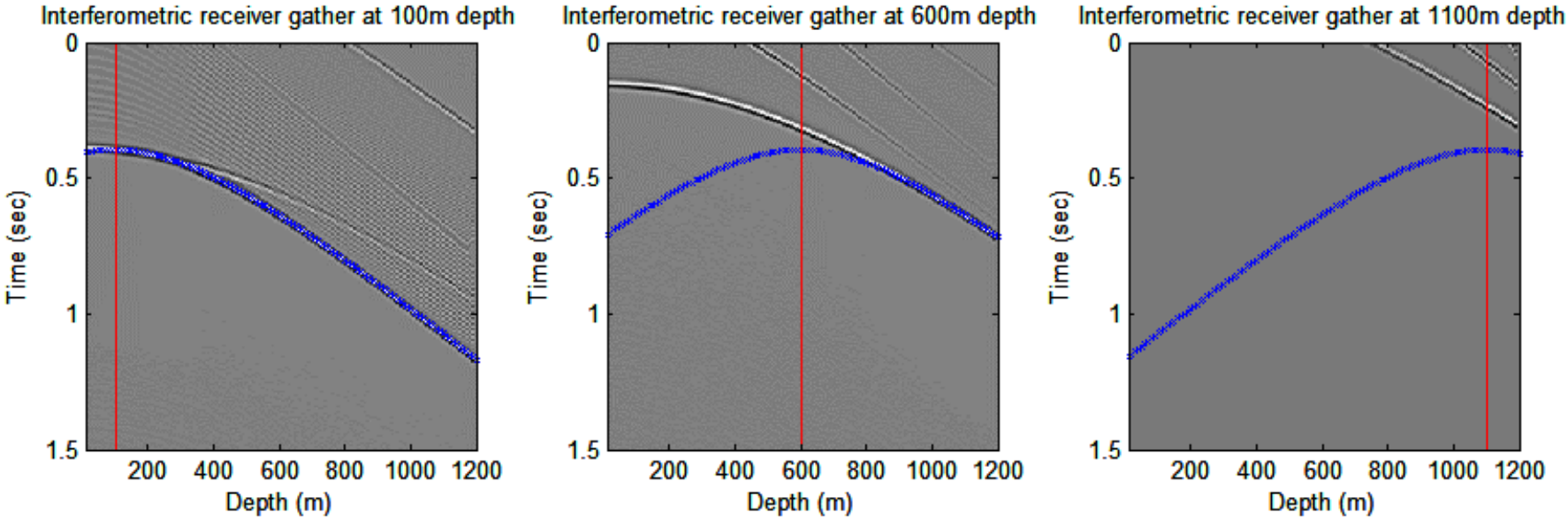
Max offset 1000m

Aperture effect: reflected P waves



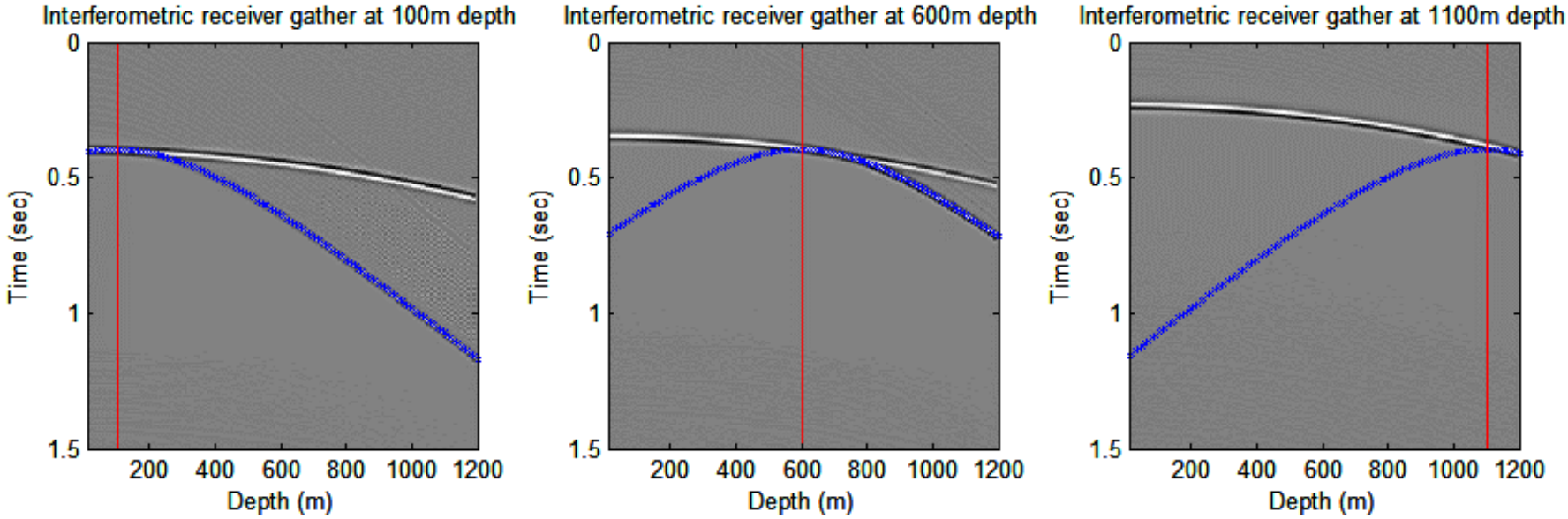
Max offset 4000m

Aperture effect: direct S waves



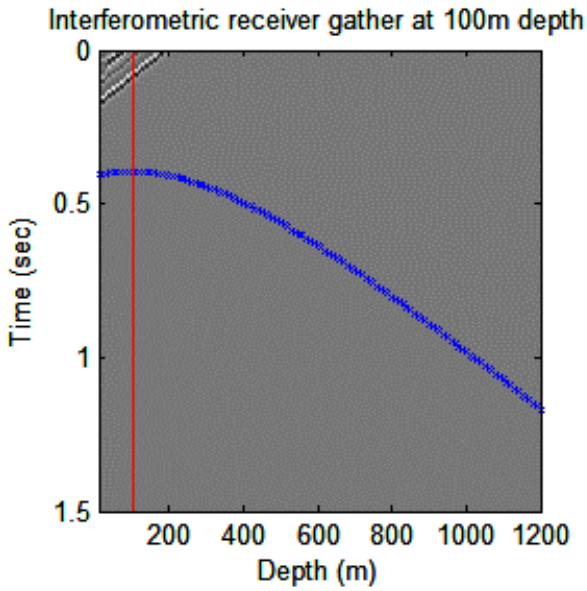
Max offset 1000m

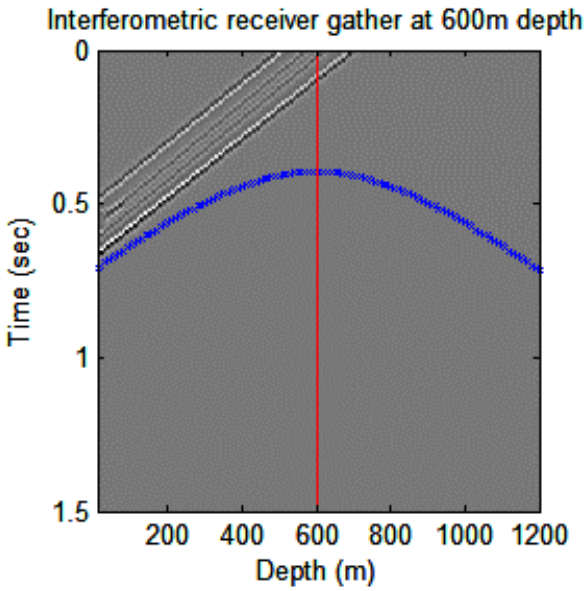
Aperture effect: direct S waves

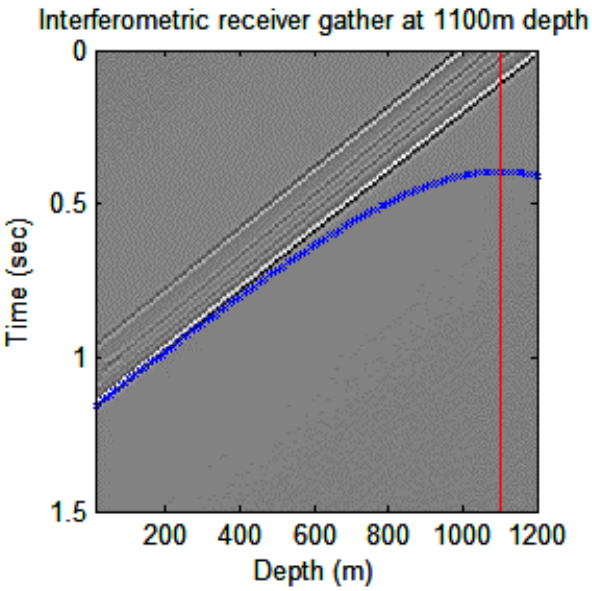


Max offset 4000m

Aperture effect: converted S waves

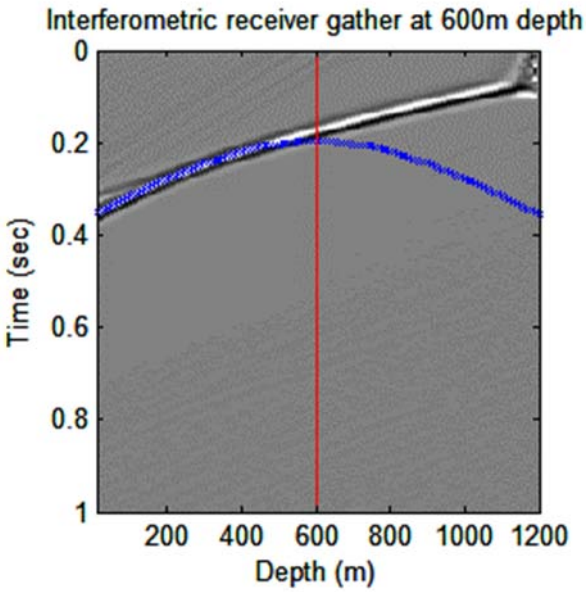




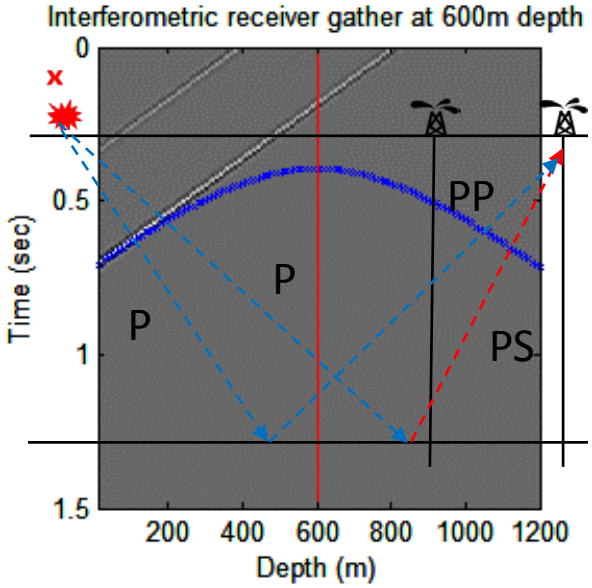


Max offset 1000m

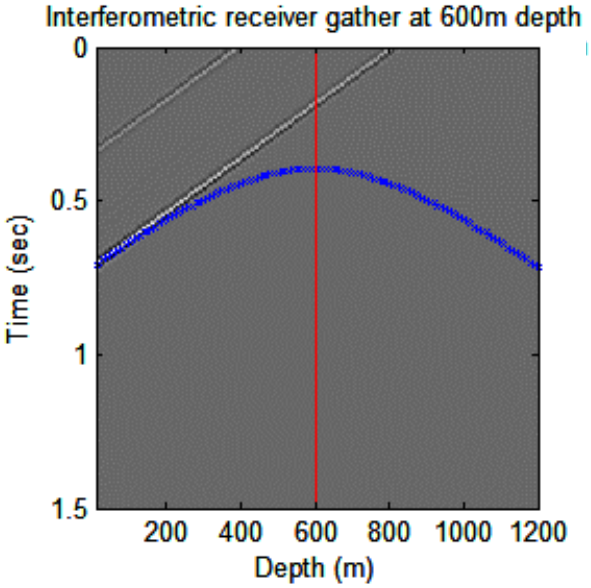
Aperture effect: converted S waves



Reflected P waves



Max offset 4000m



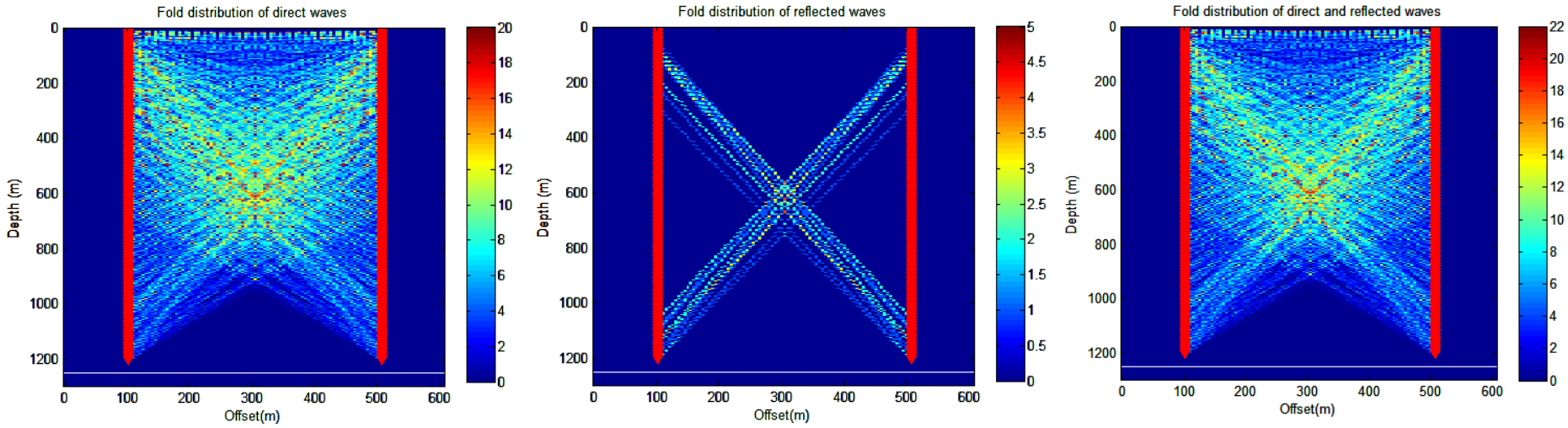
Converted S waves

Results

Fold distribution

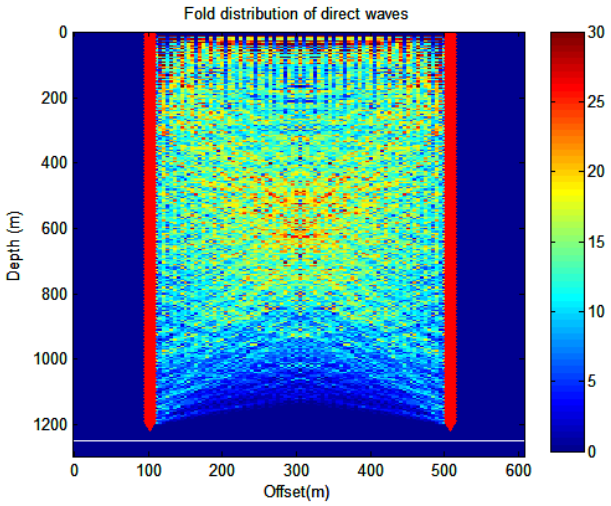
- 1000m and 4000m maximum offsets
- Maps of the direct waves, reflected waves and the summation of both

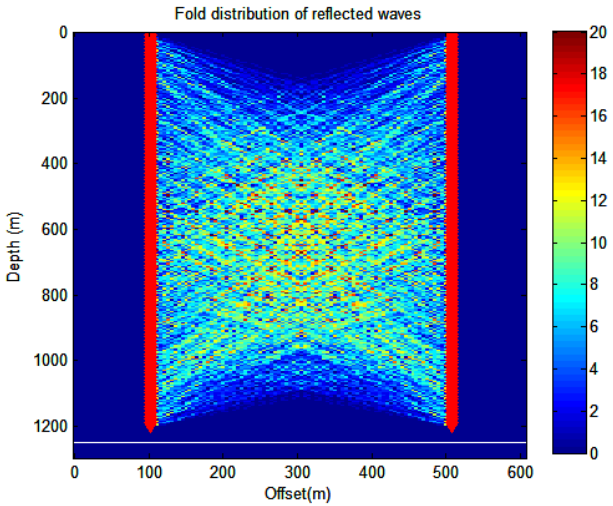
Fold distribution: P waves

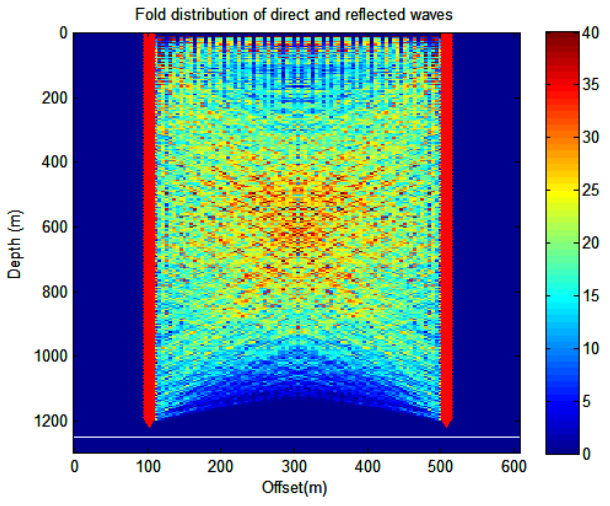


Max offset 1000m

Fold distribution: P waves

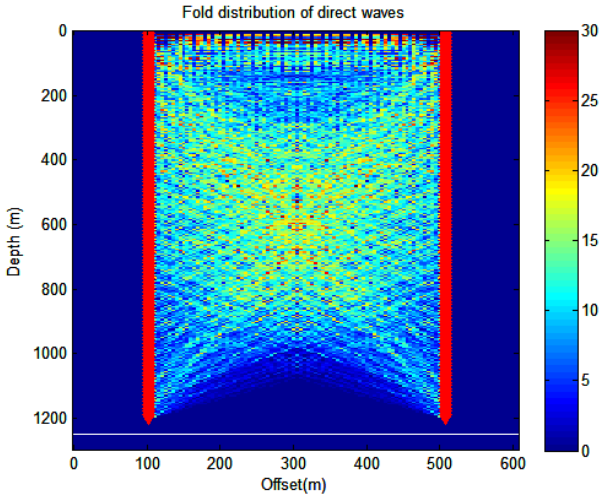


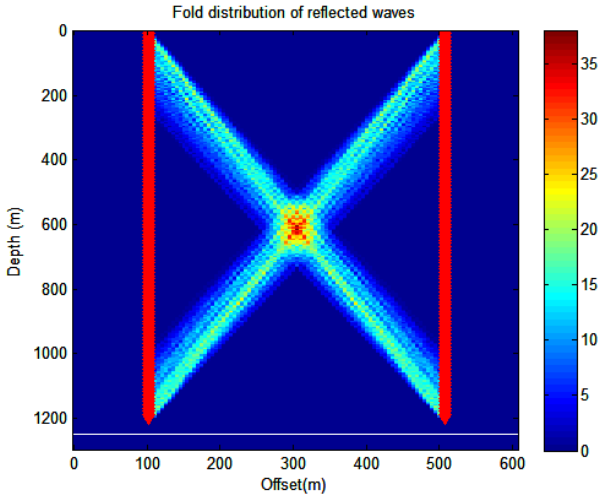


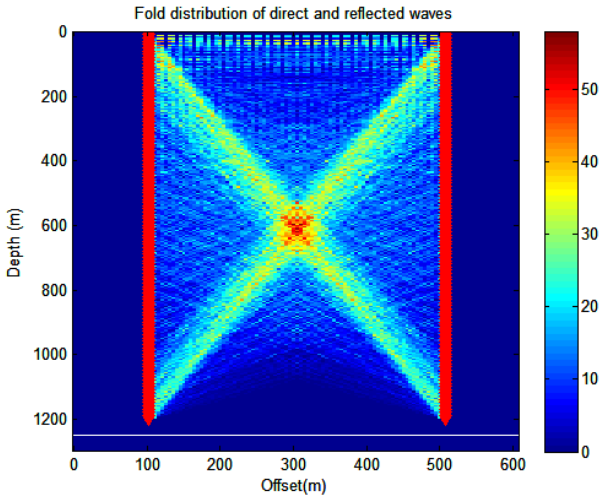


Max offset 4000m

Fold distribution: S waves

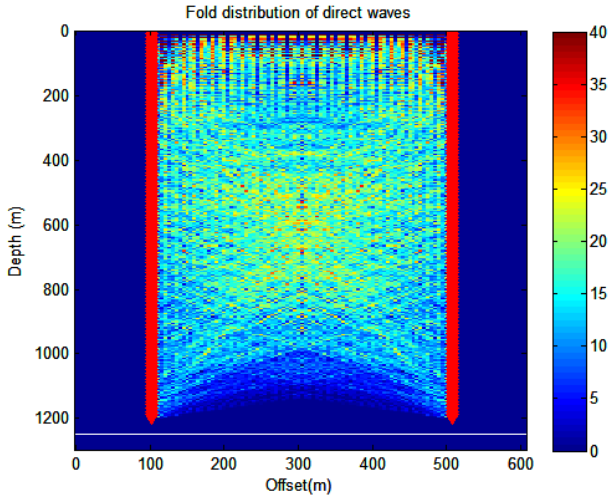


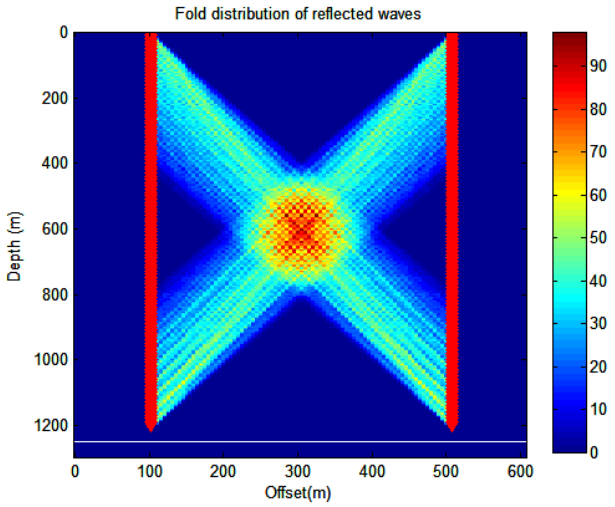


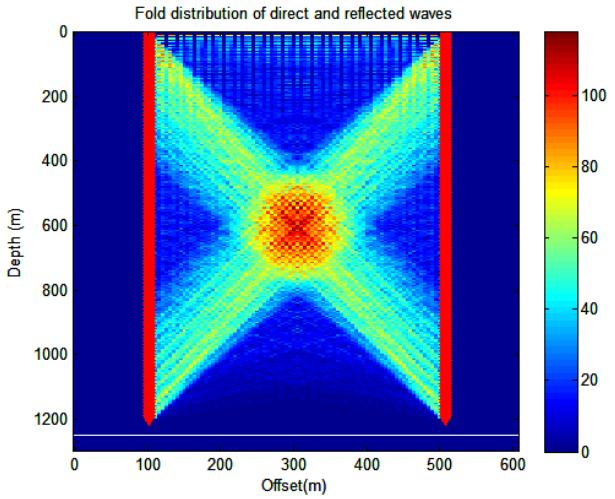


Max offset 2000m

Fold distribution: S waves







Max offset 4000m

Conclusions and future work

The use of seismic interferometry is helpful to reconstruct crosswell information that was not available with the conventional methods.

The analysis of the aperture effect showed that while the maximum offset increases the relation between the timing of the pseudo-traces and the raytraced traveltime improves.

Results show that while increasing the maximum offset we were able to reach deeper parts of the model in the fold distribution.

These achievements provide an opportunity to attempt towards seismic tomography for computing P and S wave velocity models between the two wells.

Acknowledgments

CREWES

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CREWES staff and students

Thank you,

any questions