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UNIVERSITY OF CALGARY

Shear wave attenuation measurements from converted-wave VSP data

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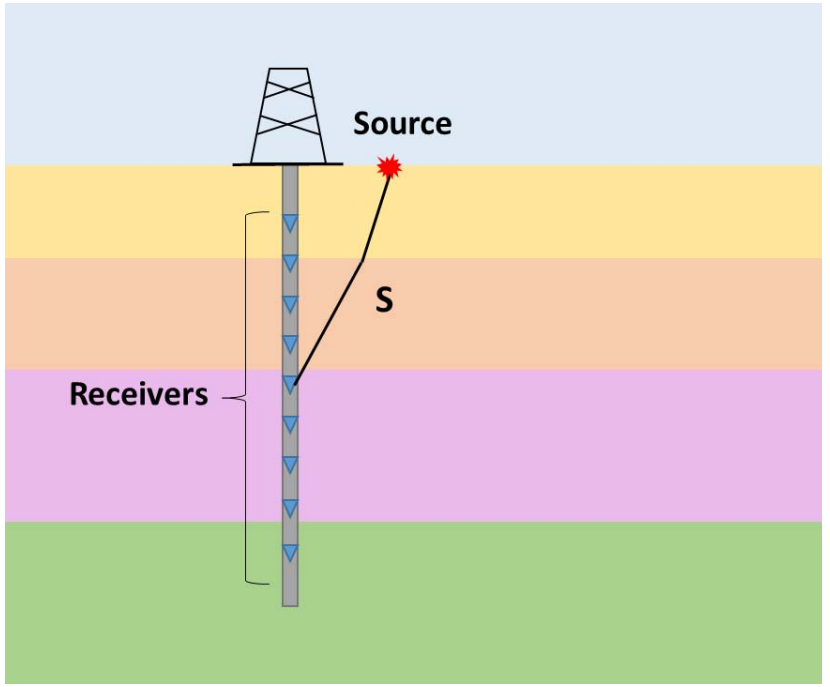
Don C. Lawton
Gary F. Margrave

Outline

- Introduction
- Theory
  - Hodogram rotation
  - Spectral-matching method
- Analysis and results
- Conclusions
- Acknowlegments

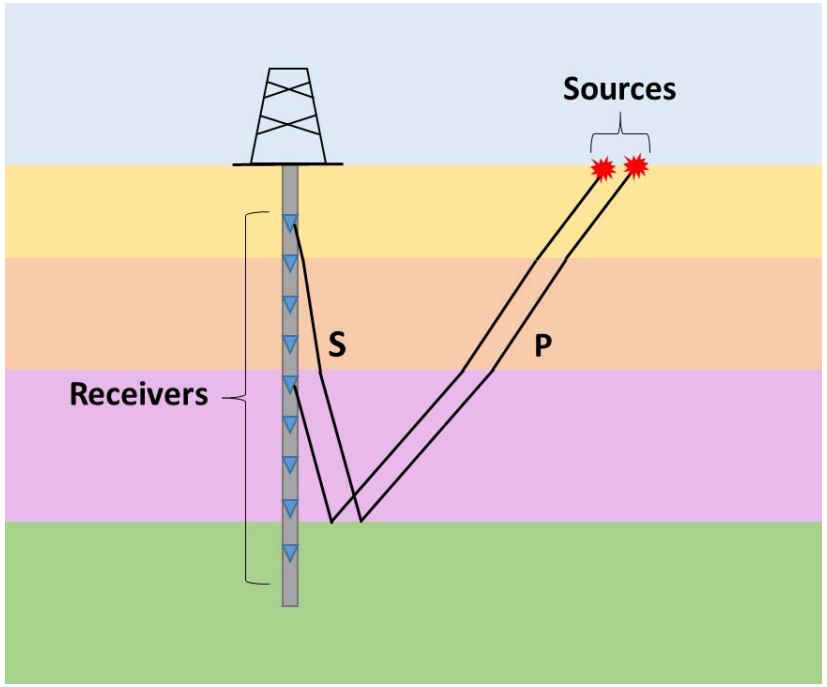
Introduction

- Shear wave attenuation can be measured from down-going shear waves in VSP data (Montano et al., 2014).
- Direct shear waves are not always easy to identify.
- Direct shear waves have to travel through the near surface.

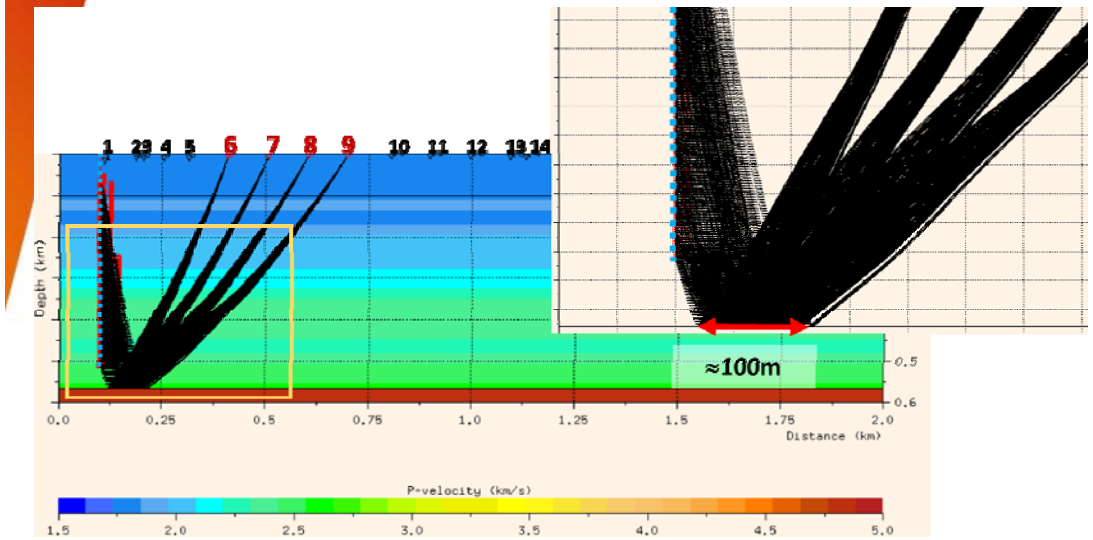


Introduction

- Estimate Q_S through exploiting converted-waves (P-S) reflections.
- The initial S-waves at the conversion point has the same bandwidth as the incident P-wave.



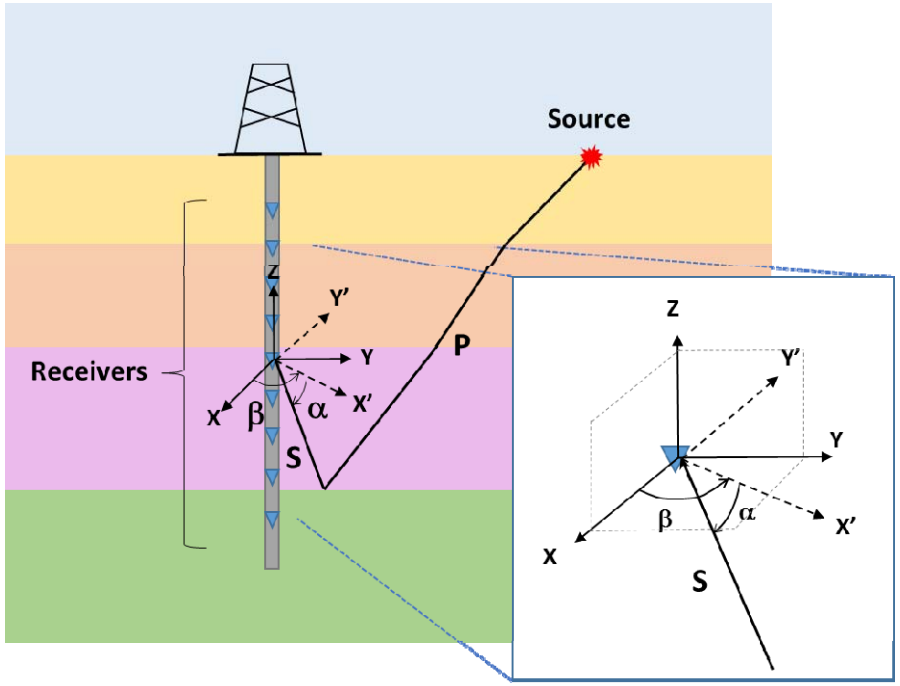
Introduction



Ray-tracing for shot points 6 – 9 using NORSAR2D software

- For this study, we estimated Q from the shot points: 6 to 9.
- Converted shear waves show a close to vertical raypath after reflection.
- Common conversion points (CCP) are very close together for different shot points.

Hodogram rotation



- **First rotation:** was computed with the horizontal components, X and Y.
- **Second rotation:** was computed using the vertical and horizontal components, Z and X' (Hmax) respectively.

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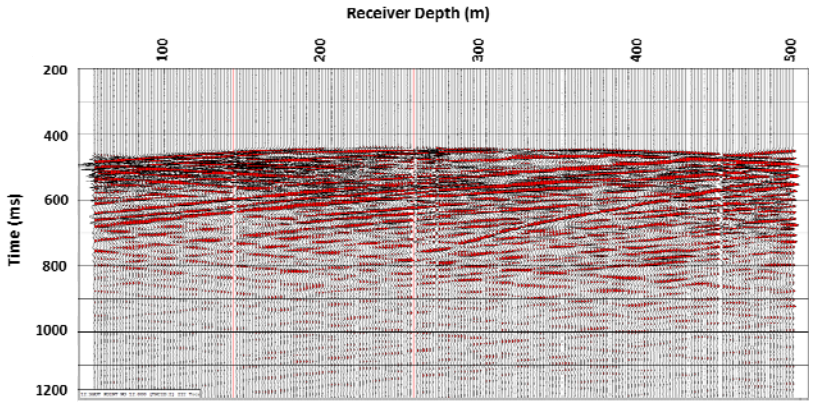
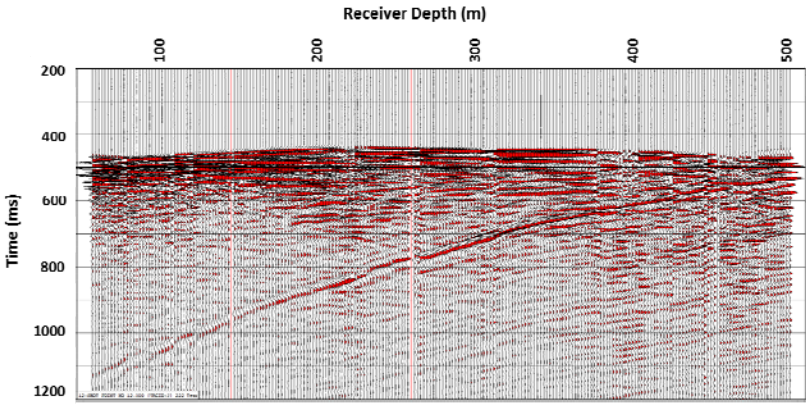
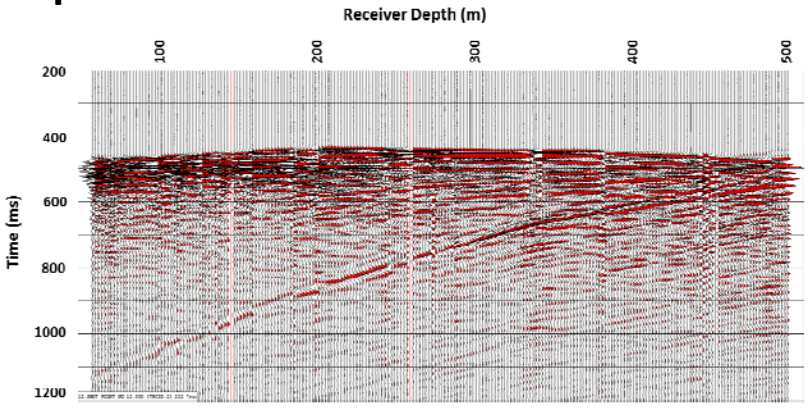
Vertical component

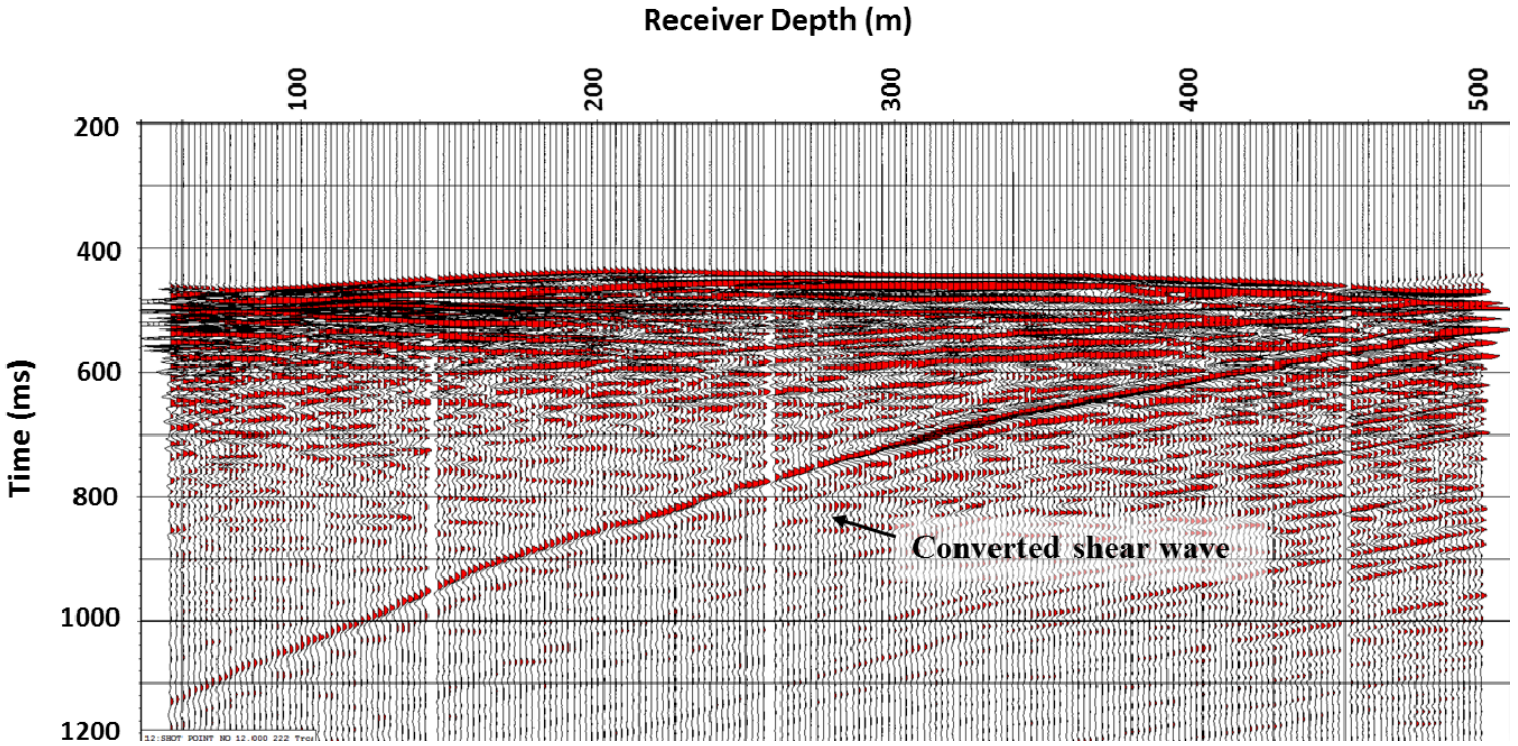


Horizontal components



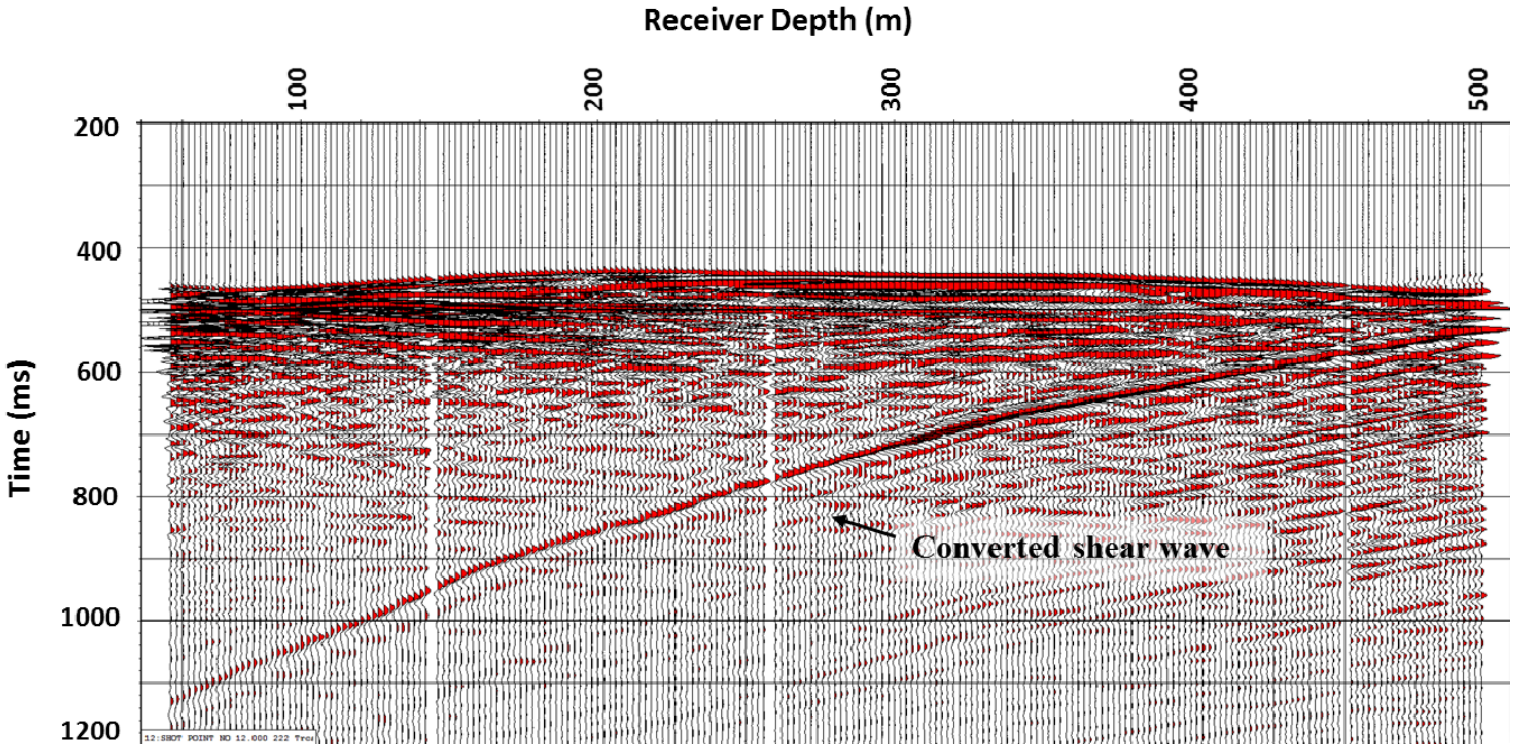


Hodogram rotation



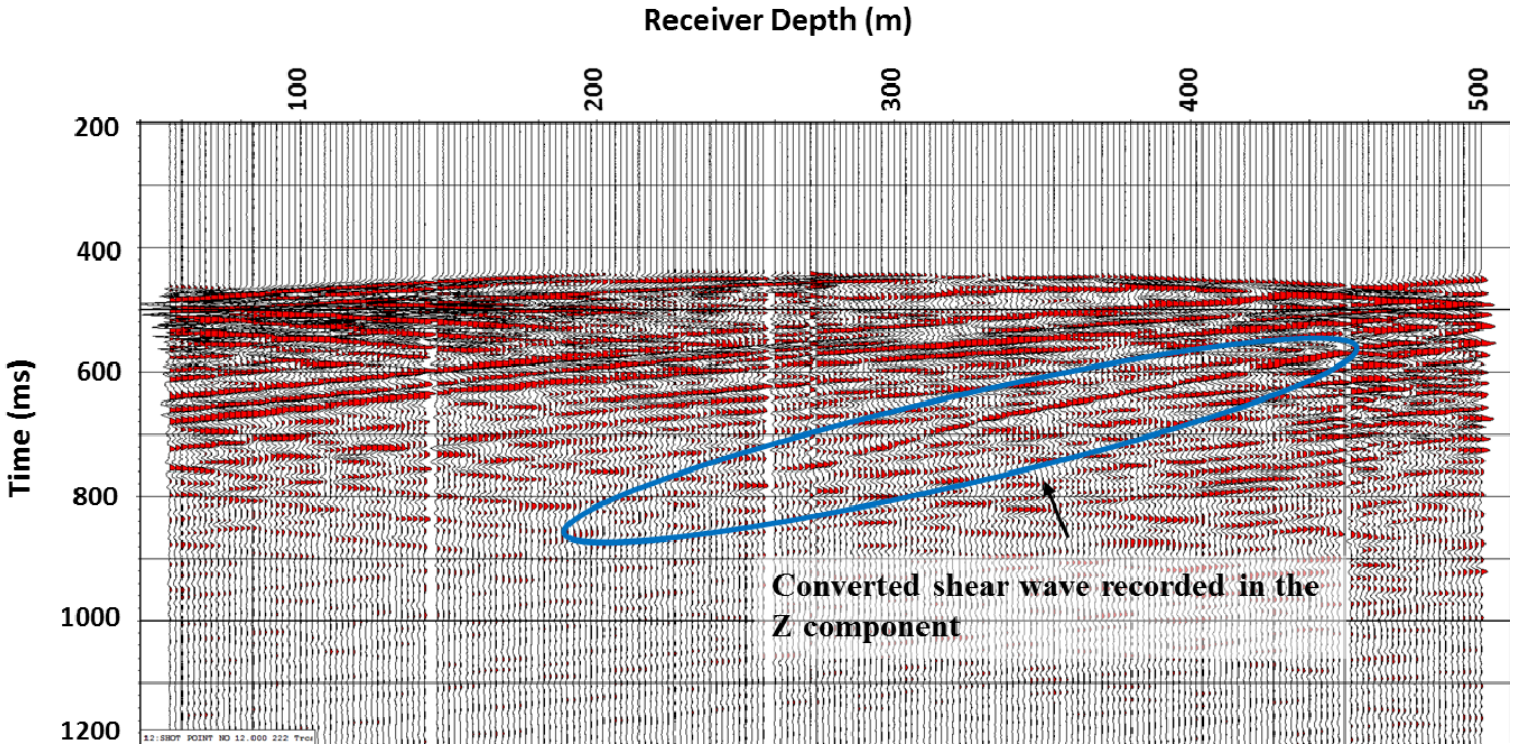
Horizontal component after 1st rotation (Hmax)

Hodogram rotation



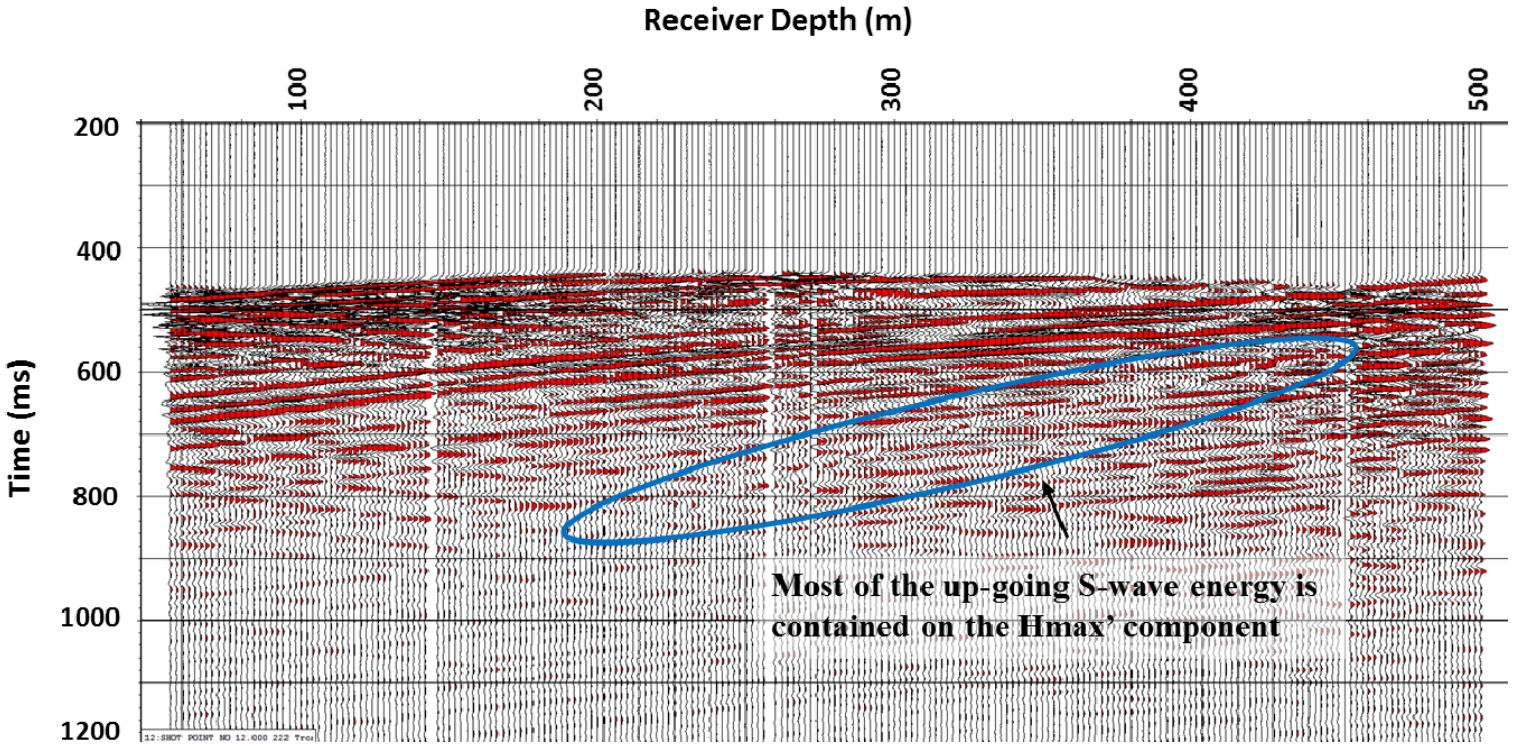
Horizontal component after 2nd rotation (Hmax')

Hodogram rotation



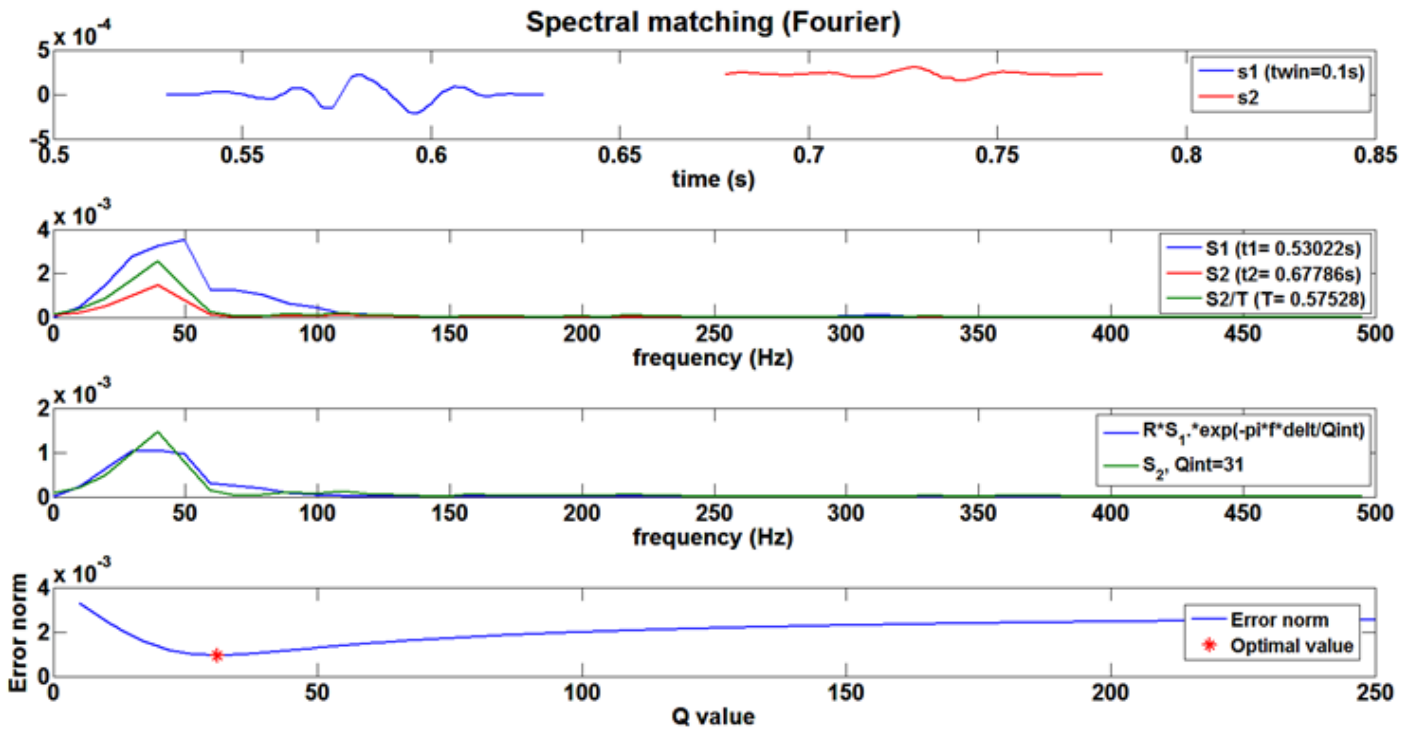
Z component (Raw Vertical)

Hodogram rotation



Z component after 2nd rotation (Raw Vertical')

Spectral-matching method



Margrave, G. F., 2013, Q tools: Summary of CREWES software for Q modelling and analysis

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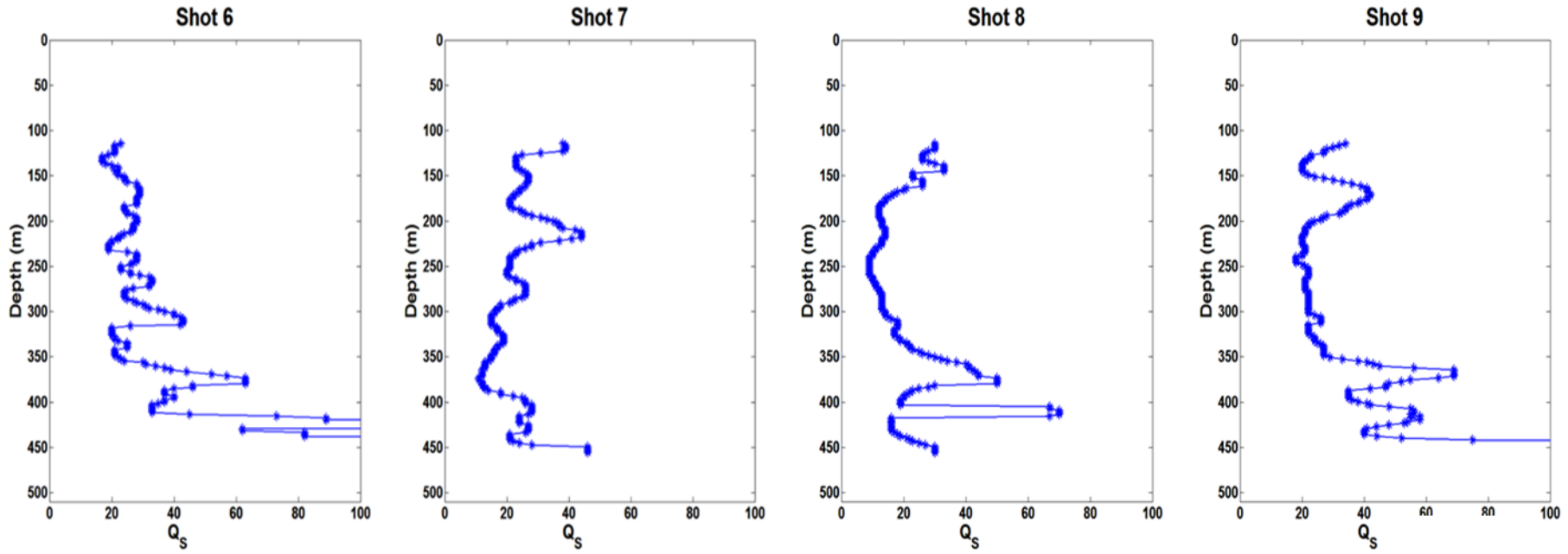
Analysis and Results

Q_S estimation for shot points 6 - 9



Spectral-matching method

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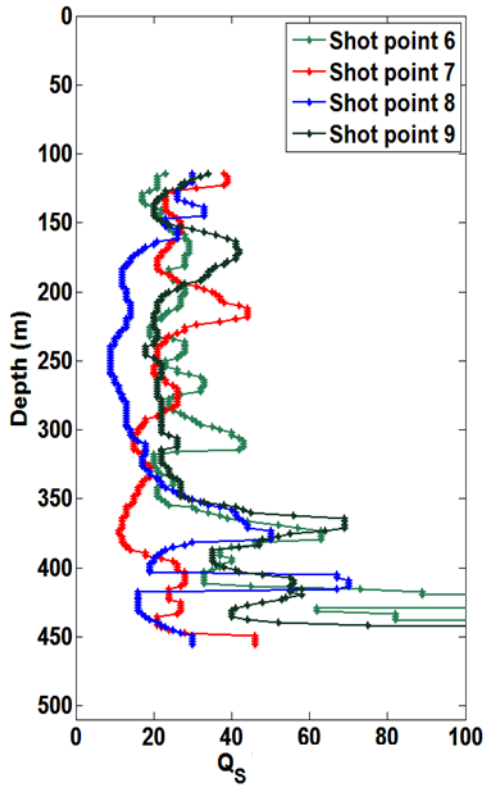
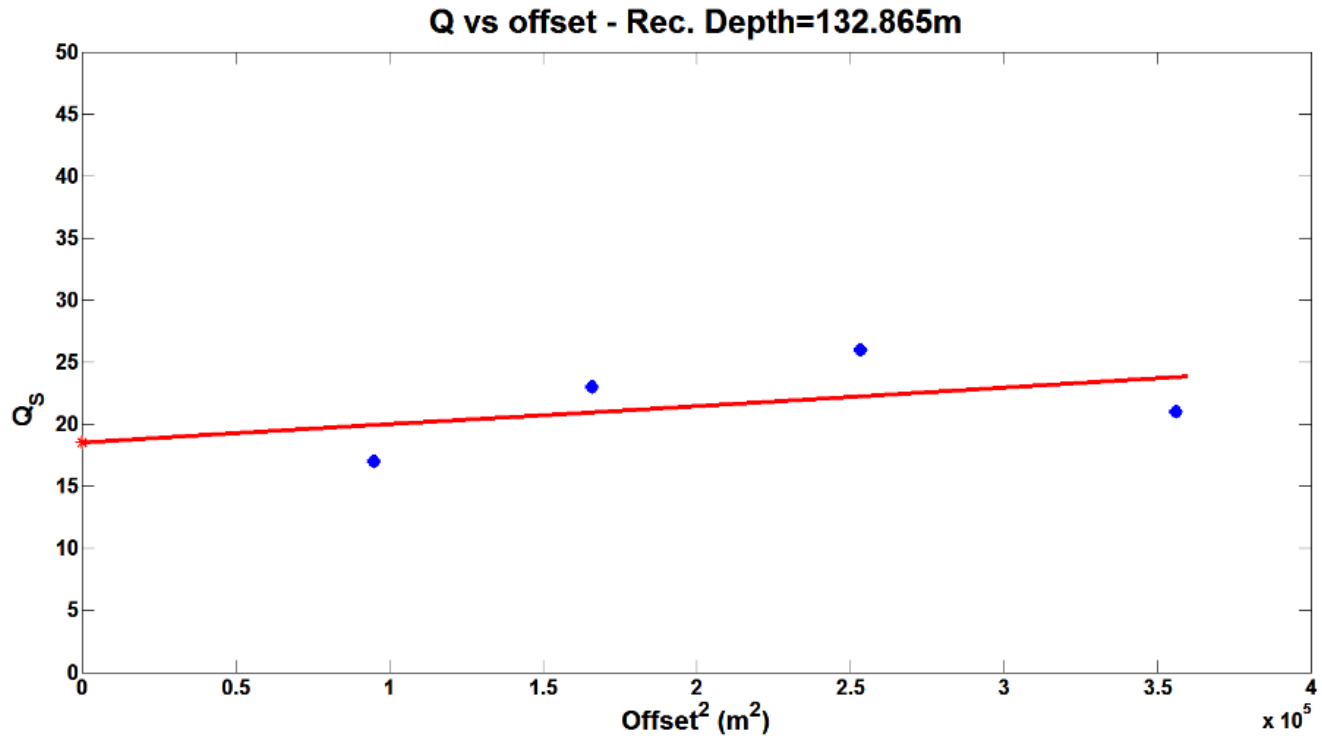
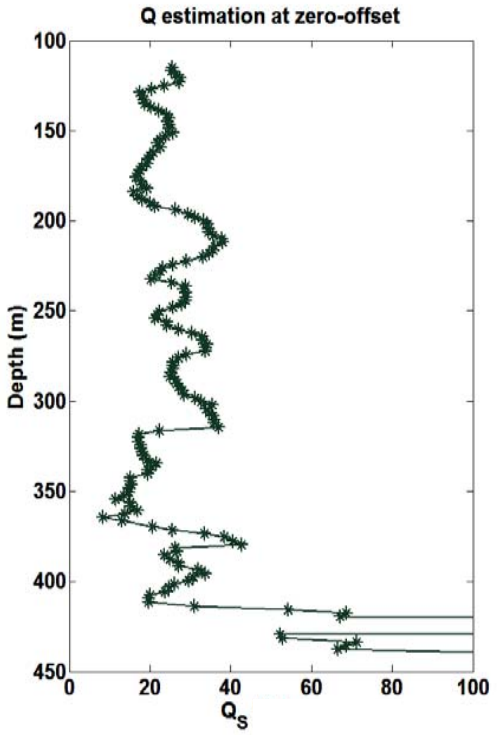


QVO method



Dasgupta R. and Clark R. A., 1998.

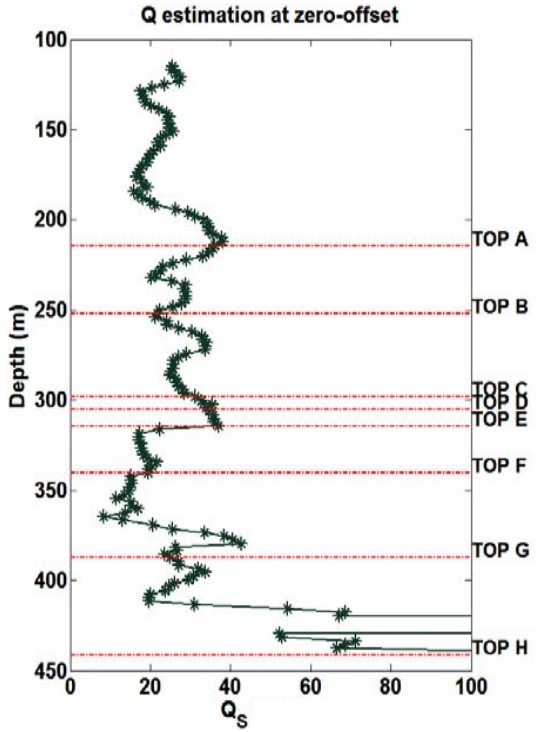
Q_S estimation at zero-offset



Q_S estimation at zero-offset

- After computing Qs for each shot point, we estimated Qs at zero-offset by using the QVO method.
- We observed a strong correlation between Qs estimation and the formation tops.
- We also noticed a decrease in QS values from 320m to 370m depth.

Q_S estimation at zero-offset



Q_S estimation at zero-offset
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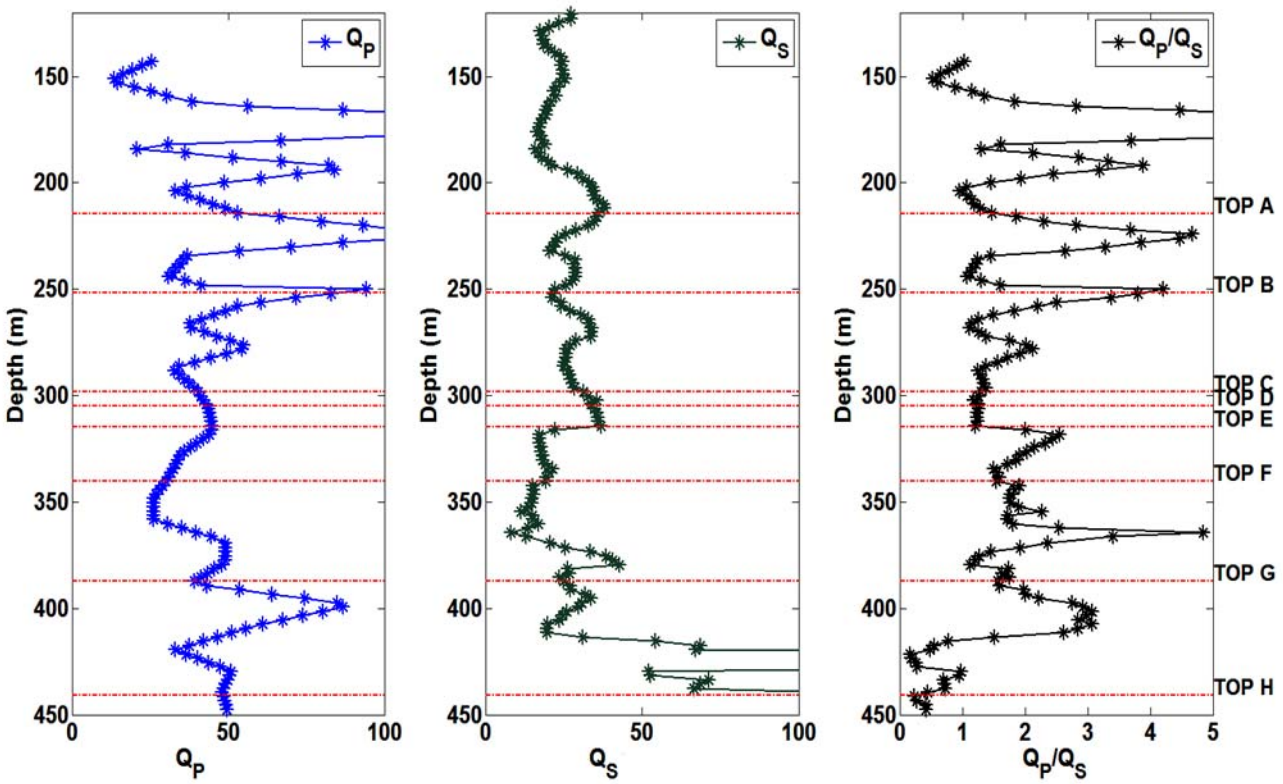
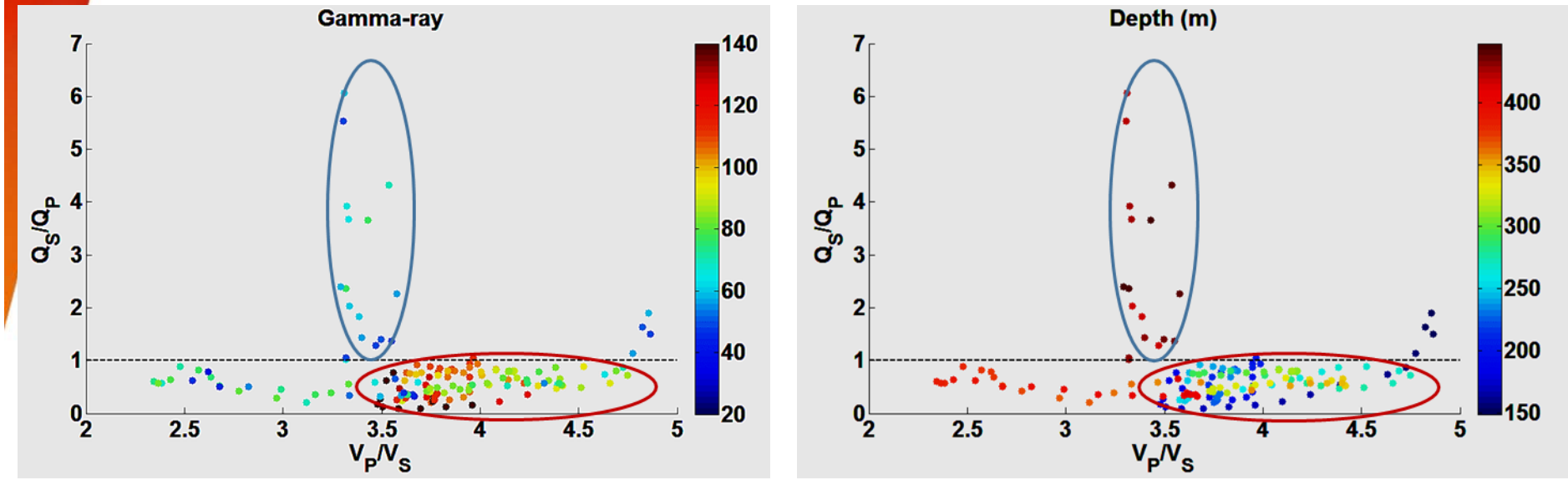
Comparing Q_P versus Q_S



Comparing attenuation versus velocity



Winkler K. W. and Nur A., 1982

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Conclusions

- Add near-surface receivers to estimate Q in that depth.
- Converted-wave data may help us to obtain more reliable Q_S estimation than direct shear wave.
- Using hodogram rotation for converted-wave VSP data is a good alternative when we have uncertainty in the velocity model.
- QVO method helped us to convey our Q_S estimations from VSP converted-wave data. Q_S values range from 20 to 50 in this study.
- Results show that we can compare seismic attenuation versus velocities to identify fluid saturation variation in rocks.

Acknowledgements

- CREWES sponsors
- NSERC through grant CRDPJ 461179-13
- Anonymous company for access to the field VSP data
- GEDCO/Schlumberger for VISTA software
- NORSAR for NORSAR-2D software
- CREWES faculty, students and staff

References

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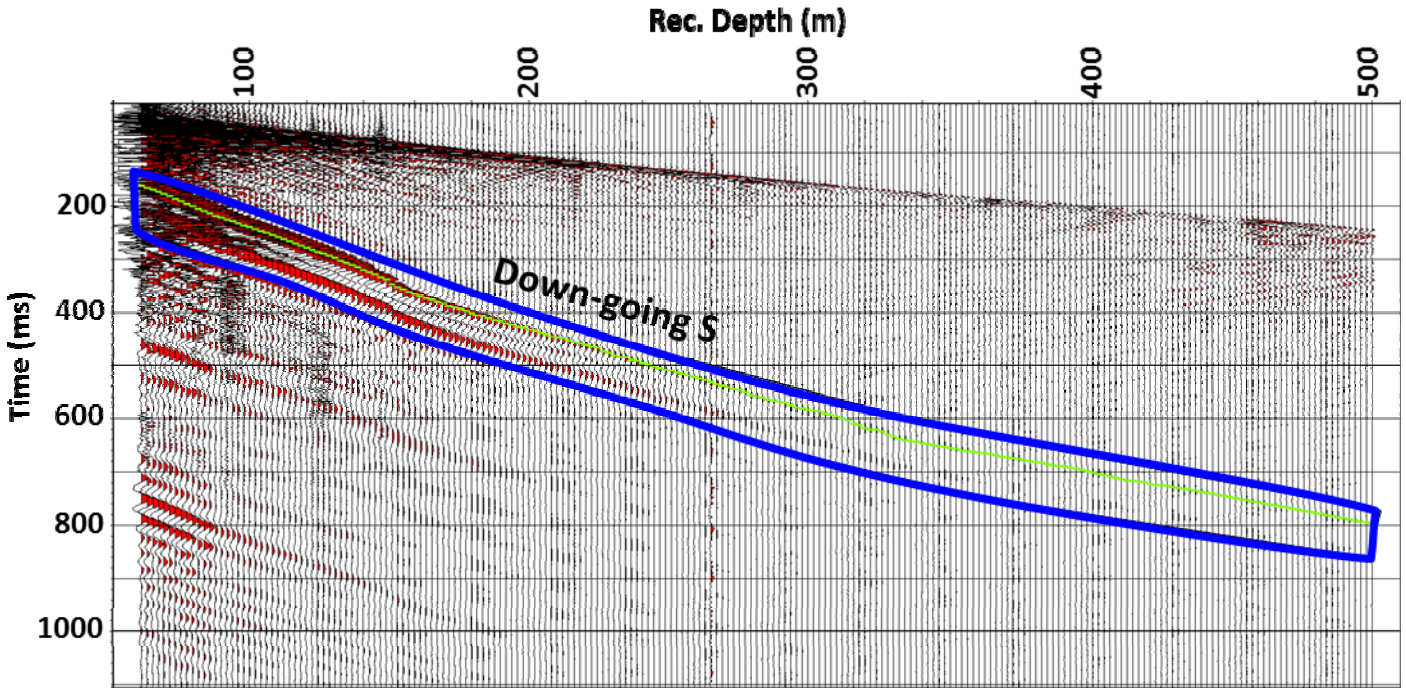
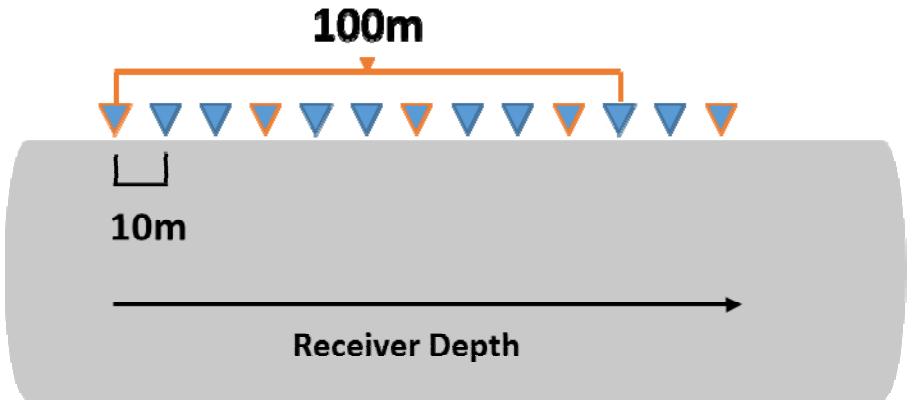
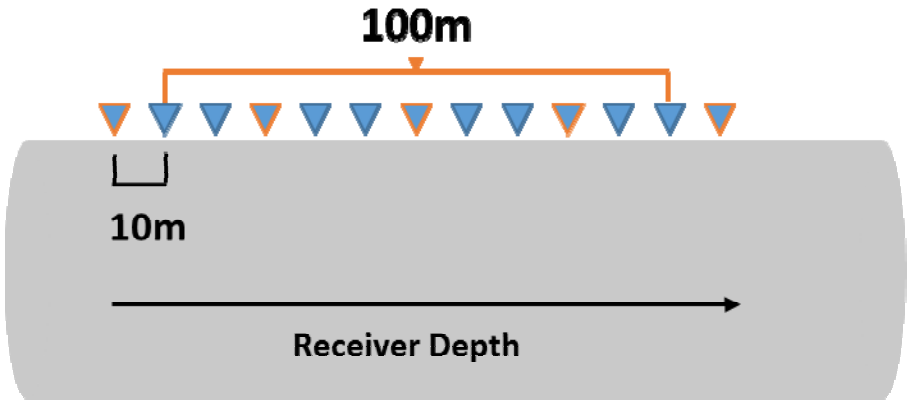
Future work

- Further study about the relationship between seismic attenuation and rock properties is needed. These values can be used to estimate gas saturation and lithology discrimination, among other properties.
- We will estimate Q in a deeper data set with more layers and noise. For this case, we will need to apply a stronger filter to remove noise and separate the wave-field. The challenge will be to pre-process the data set without changing the amplitudes. Then, we will be able to obtain some reliable Q estimation by applying the same methods.
- Convey Q estimation using harmonic mean.


Rec. Depth (m)
100
200
300
400
500
Time (ms)
200
400
600
800
1000
Down-going S


100m
10m
Receiver Depth


100m
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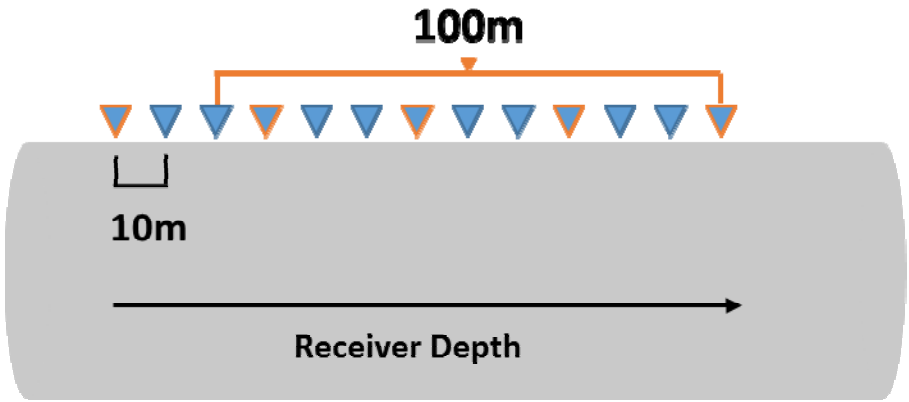
Receiver Depth


100m
10m
Receiver Depth

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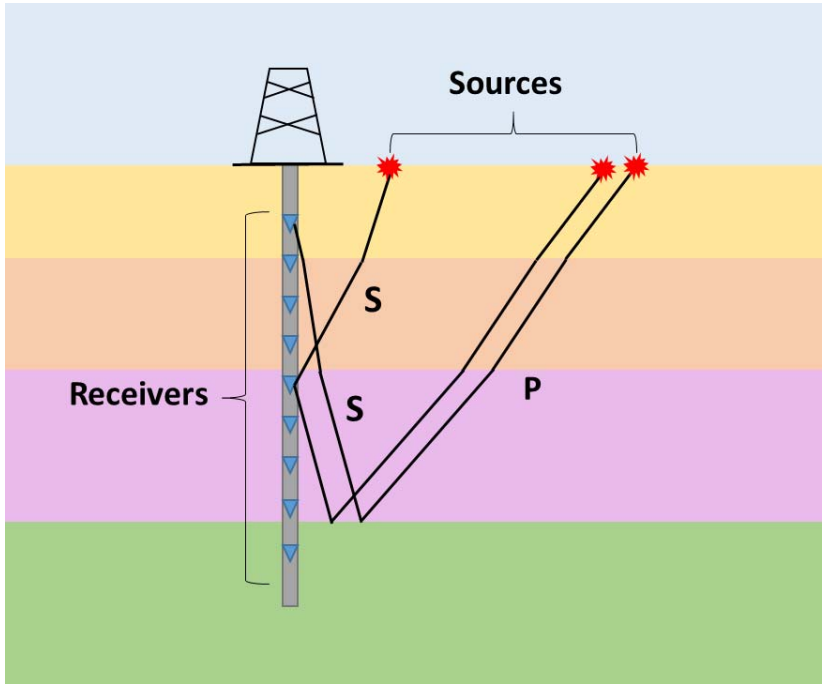

Processing work flow

- Step 1 • Geometry
- Step 2 • First Breaks and up-going events picking
- Step 3 • Hodogram rotation
- Step 4 • Wave-field separation
- Step 5 • Q estimation from walkaway VSP data
- Step 6 • Q estimation at zero-offset (QVO method)

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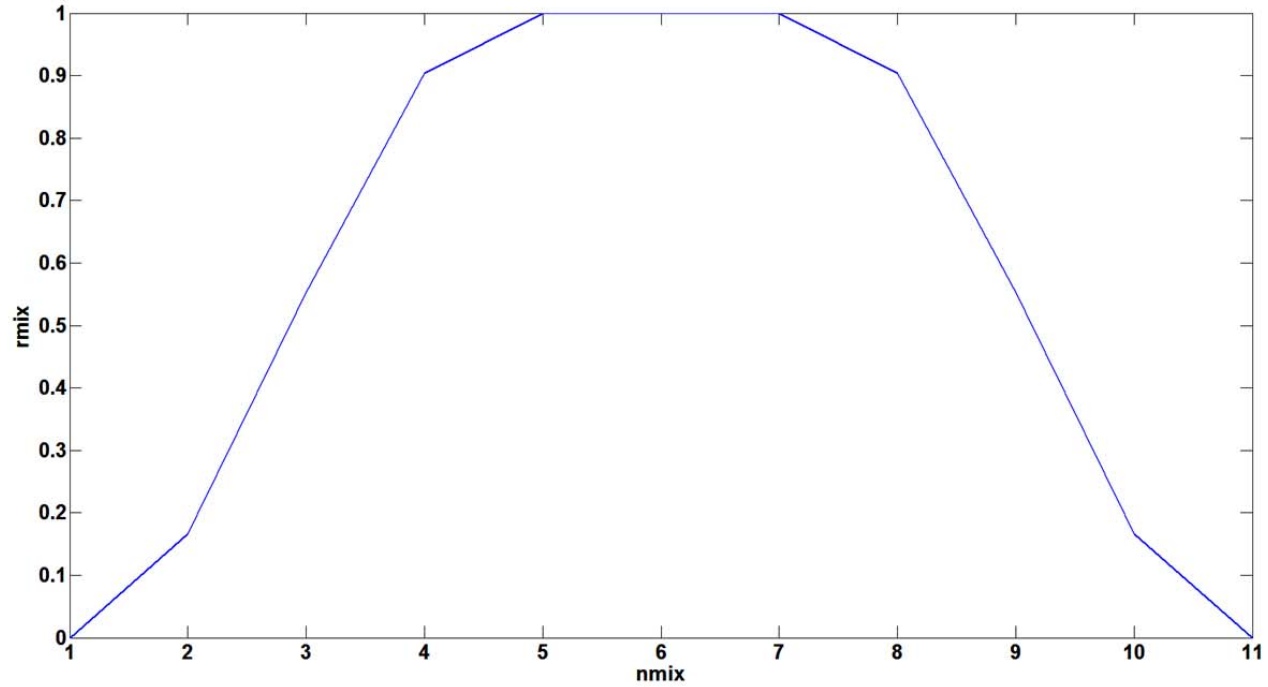
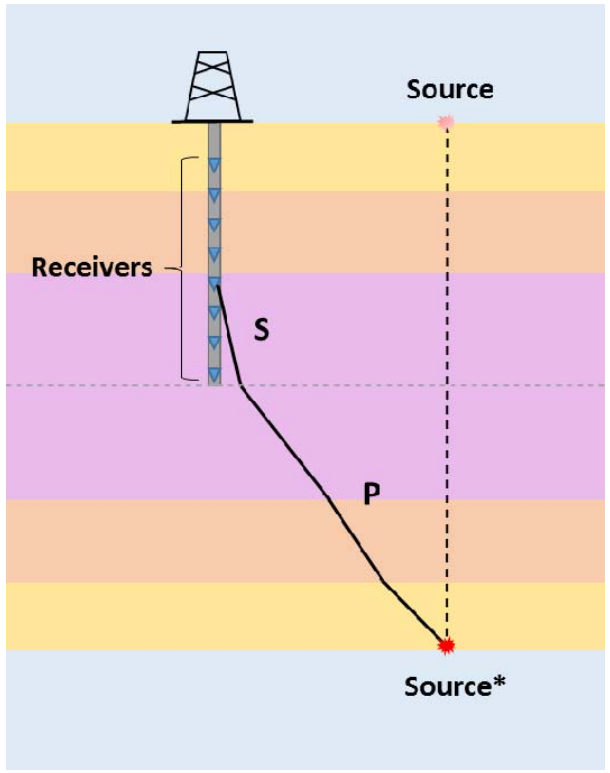
- **Receivers: 222 at 2m spacing (60-500m depth).**

Shot	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Offset (m)	12	88	105	153	214	**308**	**408**	**503**	**597**	703	798	897	993	1030

Cosine-tapered window




Source
Receivers
S
P
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