Elimination of seismic multiples by anisotropic, prestack depth migration and filtering

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Outline

- Introduction.
- Theory.
- Examples.
- Conclusions.
- Acknowledgements.

Introduction

- Assume that $\psi_P(\mathbf{x}, t)$ and $\psi_M(\mathbf{x}, t)$ are a superposition of Huygens point scatterers.
- Given $v_{\mathrm{H_2O}}$, focus WB multiples with ZOM, erase, un-focus.
- Derive group and phase velocity for ZOM.

Theory

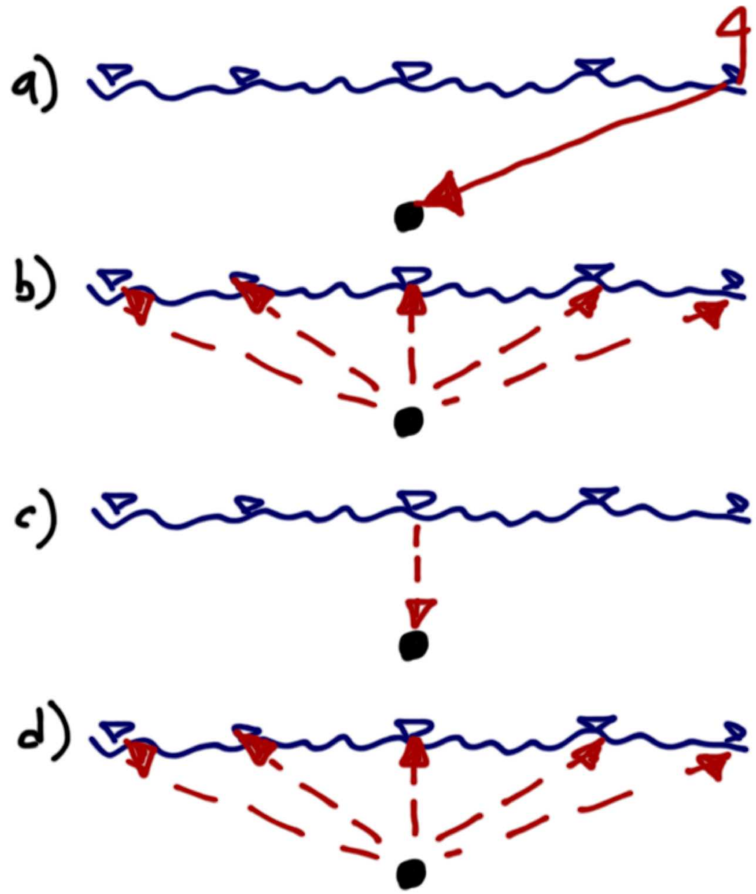
- Seafloor model: a continuum of diffractors.
- Source $\psi_S \searrow$ a diffractor.
- Primary $\psi_P \nwarrow\uparrow\nearrow^{z=0}$.
- Reflection $\psi_R \downarrow$ from $z = 0$.
- Multiple $\psi_M \nwarrow\uparrow\nearrow^{z=0}$.

a) Source raypath to a diffractor.

b) Scattering to the surface by the diffractor.

c) Surface reflection.

d) Multiple scattering.



Traveltimes

- For a diffractor at z_0 and a *mirror* diffractor at $z = 2\,z_0$, traveltimes for ψ_P and ψ_M are

$$\Delta t_0\,(x, v_0) = \frac{z_0}{v_0}\sqrt{1 + \left(\frac{x}{z_0}\right)^2},$$

and

$$\Delta t_z\,(x, v_0) = \Delta t_0\,(x) + \frac{z - z_0}{v_0}.$$

- Write ψ_M traveltime as

$$\Delta t_z\left(x, v_z\right) = \frac{z}{v_z}\sqrt{1 + \left(\frac{x}{z}\right)^2},$$

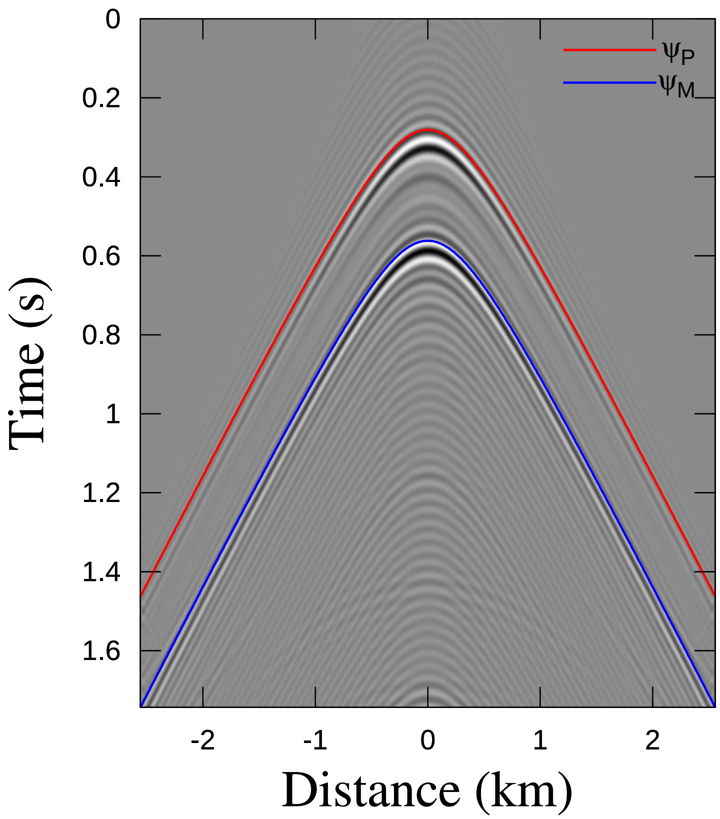
where v_z is associated with $mirror$ depth z.

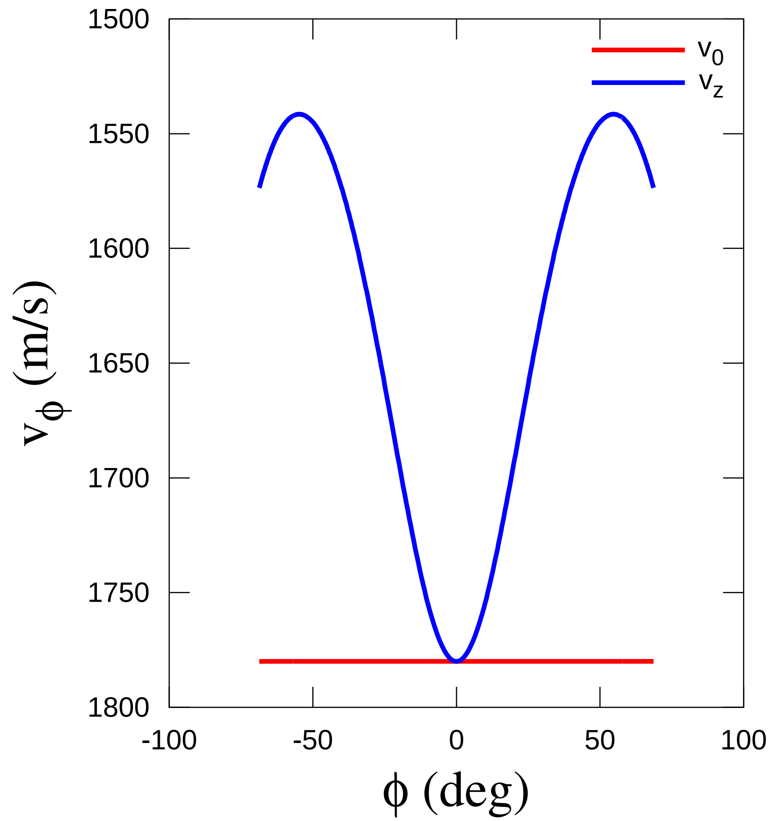
- Set $\Delta t_z\left(x, v_z\right) = \Delta t_z\left(x, v_0\right)$ and solve for v_z:

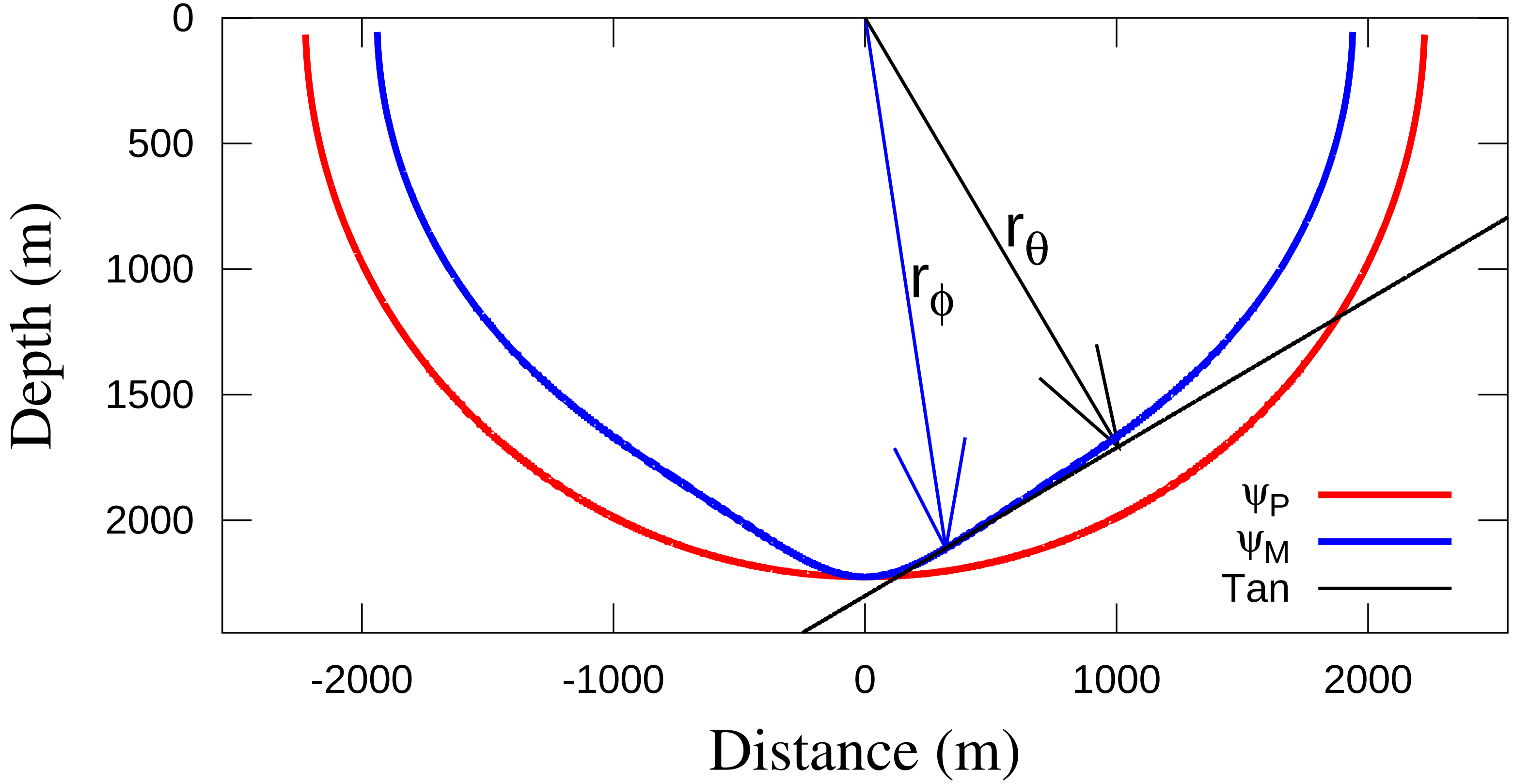
$$v_z\left(x, z, z_0\right) = z\, v_0 \frac{\sqrt{1 + \left(\frac{x}{z}\right)^2}}{z - z_0 + z_0\sqrt{1 + \left(\frac{x}{z_0}\right)^2}},$$

or in terms of group angle $\tan\phi = x/z$:

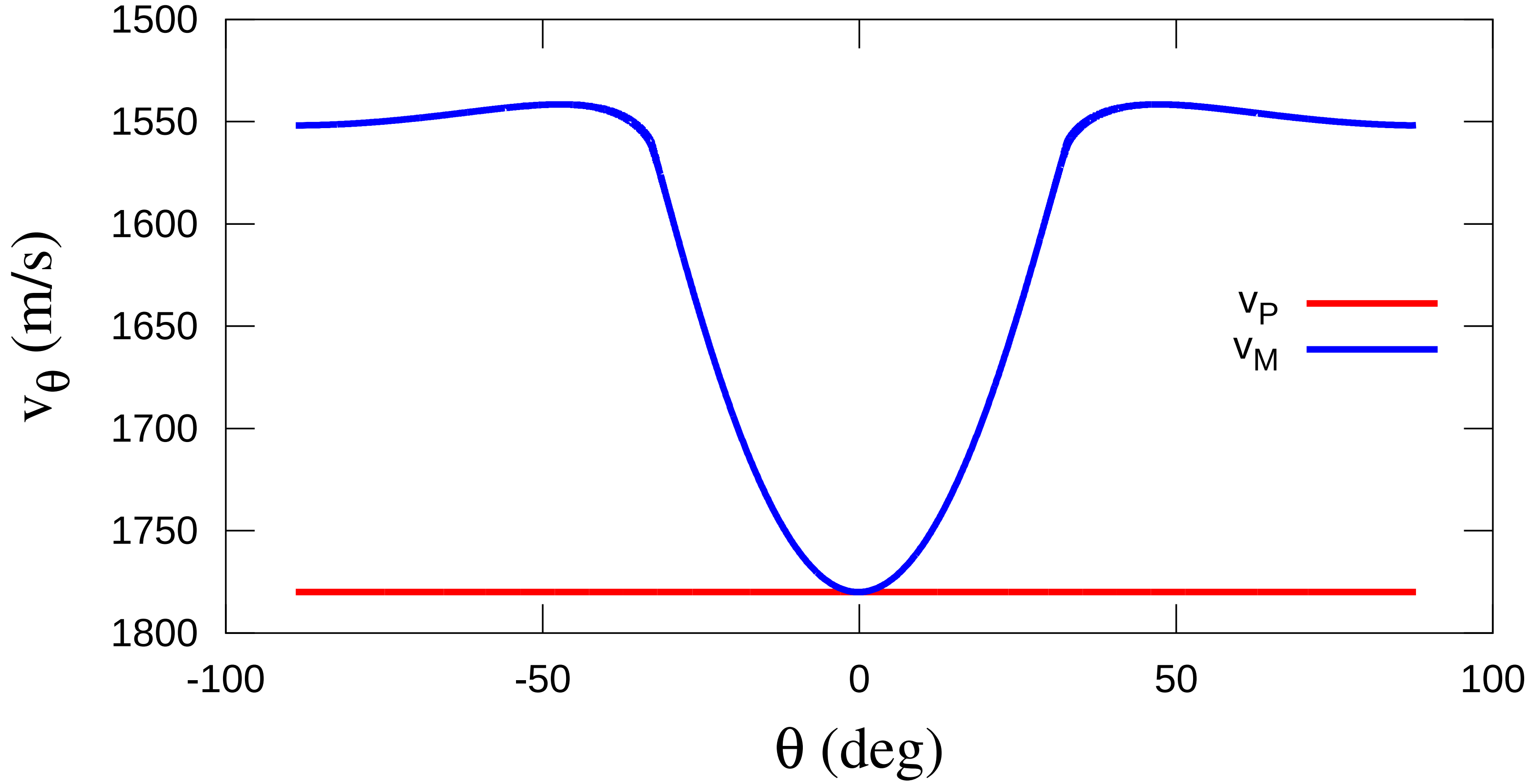
$$v_z\left(\phi, z, z_0\right) = \frac{z\, v_0}{\cos\phi\left[z - z_0 + z_0\sqrt{1 + \left(\frac{z}{z_0}\tan\phi\right)^2}\right]}$$

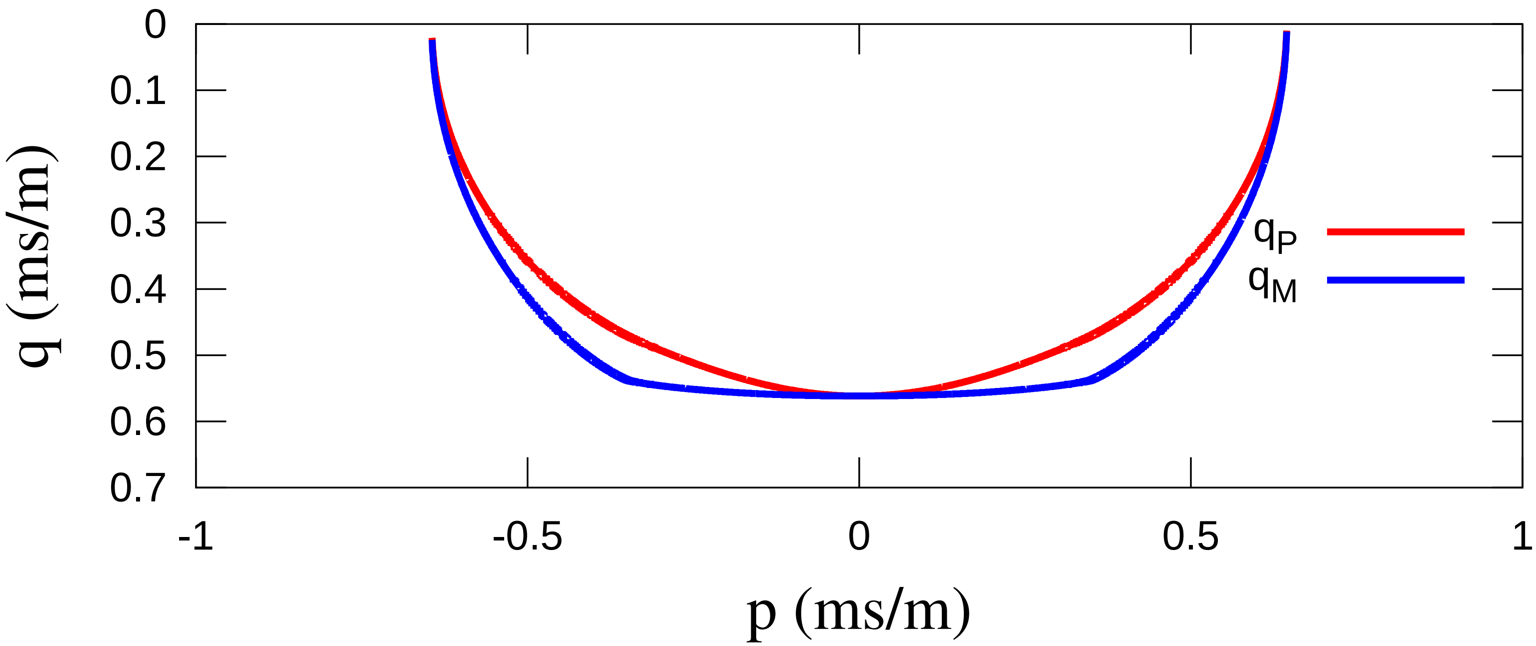

ψP
ψM
Time (s)
Distance (km)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
-2
-1
0
1
2


v0
vz
vφ (m/s)
φ (deg)
1500
1550
1600
1650
1700
1750
1800
-100
-50
0
50
100



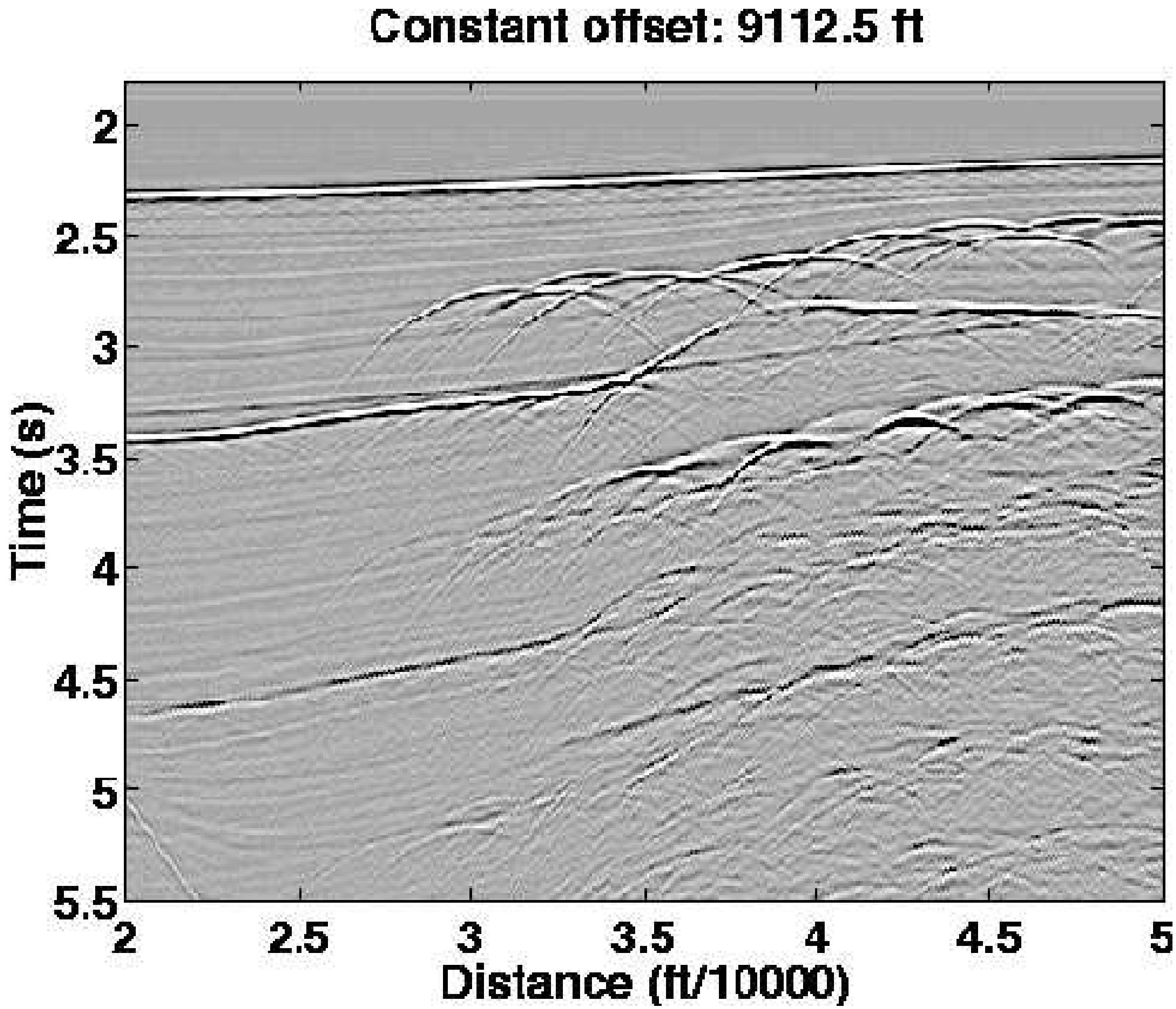
0
500
1000
1500
2000
Depth (m)
-2000
-1000
0
1000
2000
Distance (m)
r_θ
r_ϕ
ψ_P
ψ_M
Tan

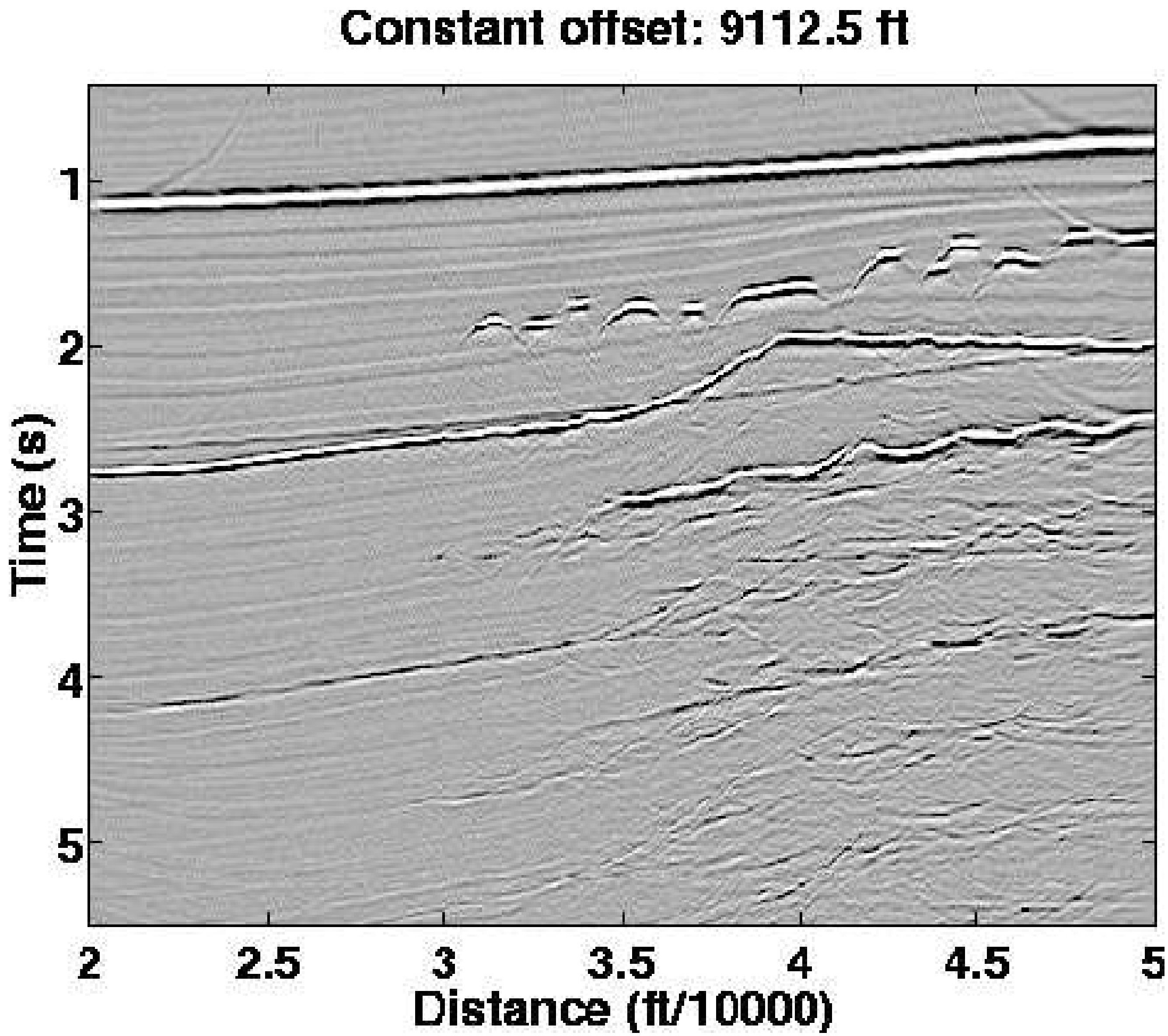

1500
1550
1600
1650
1700
1750
1800
-100
-50
0
50
100
vθ (m/s)
θ (deg)
vP
vM


0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
q (ms/m)
-1
-0.5
0
0.5
1
p (ms/m)
q_P
q_M

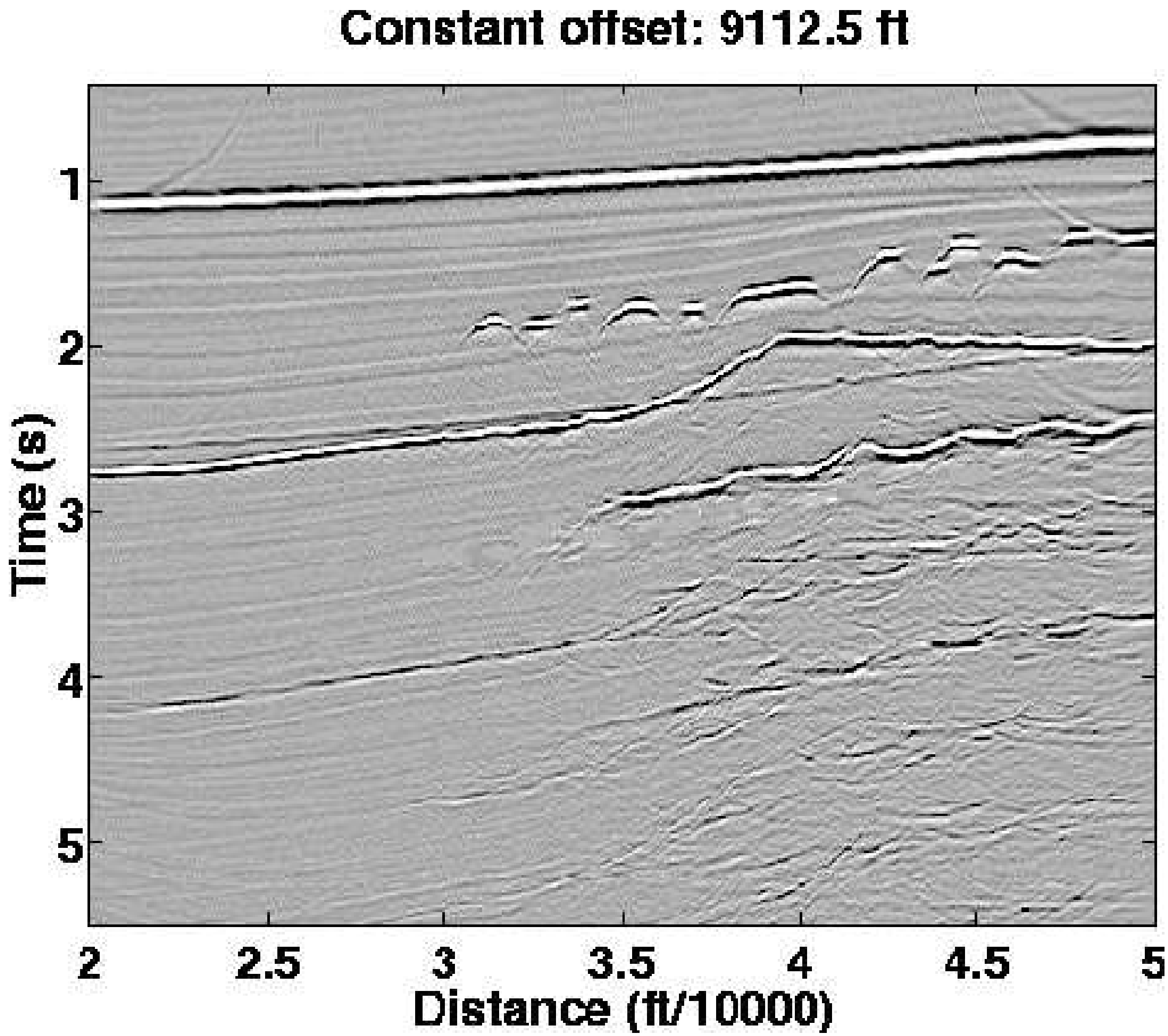
Stolt migration

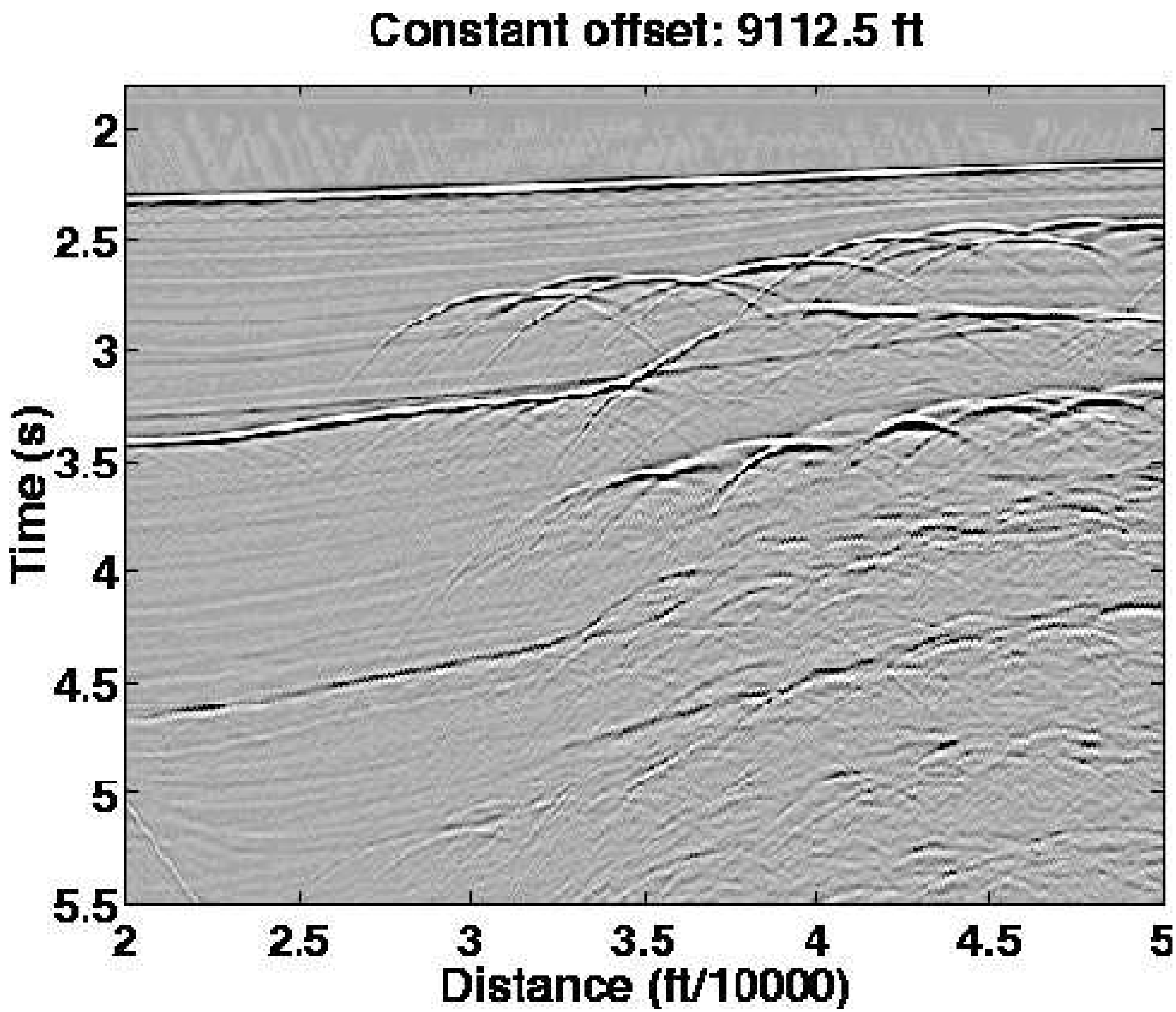
- Stolt migrate with $q\left(z_0, v_0, p\right)$.
- Assume that $\frac{d}{dx} z_0$ is small and modulate v_0 until ψ_M focus satisfactorily.
- Erase multiples.
- Inverse Stolt.

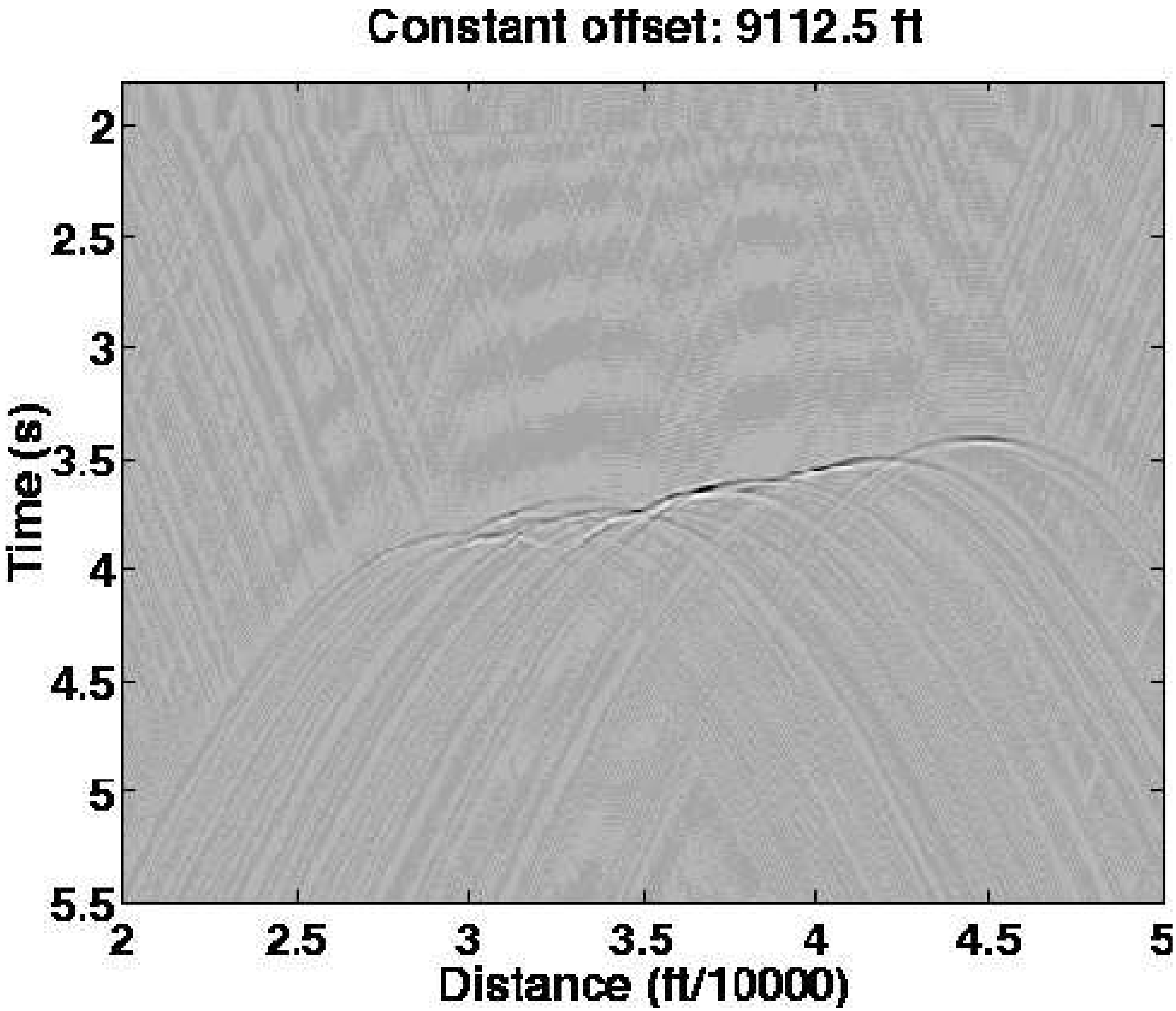

Constant offset: 9112.5 ft
Time (s)
2
2.5
3
3.5
4
4.5
5
5.5
Distance (ft/10000)
2
2.5
3
3.5
4
4.5
5



Constant offset: 9112.5 ft
Time (s)
1
2
3
4
5
2
2.5
3
3.5
4
4.5
5
Distance (ft/10000)


Constant offset: 9112.5 ft
Time (s)
1
2
3
4
5
2
2.5
3
3.5
4
4.5
5
Distance (ft/10000)


Constant offset: 9112.5 ft
Time (s)
2
2.5
3
3.5
4
4.5
5
5.5
2
2.5
3
3.5
4
4.5
5
Distance (ft/10000)


Constant offset: 9112.5 ft
Time (s)
2
2.5
3
3.5
4
4.5
5
5.5
2
2.5
3
3.5
4
4.5
5
Distance (ft/10000)

Conclusions

- Focusing velocity for WB multiples is anisotropic.
- Numerical group $\rightarrow$ phase velocity developed for use with reversible Stolt migration.
- Focus multiples, erase, unfocus.

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