Multiples in Image Space

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SEP120 pages: 365-376

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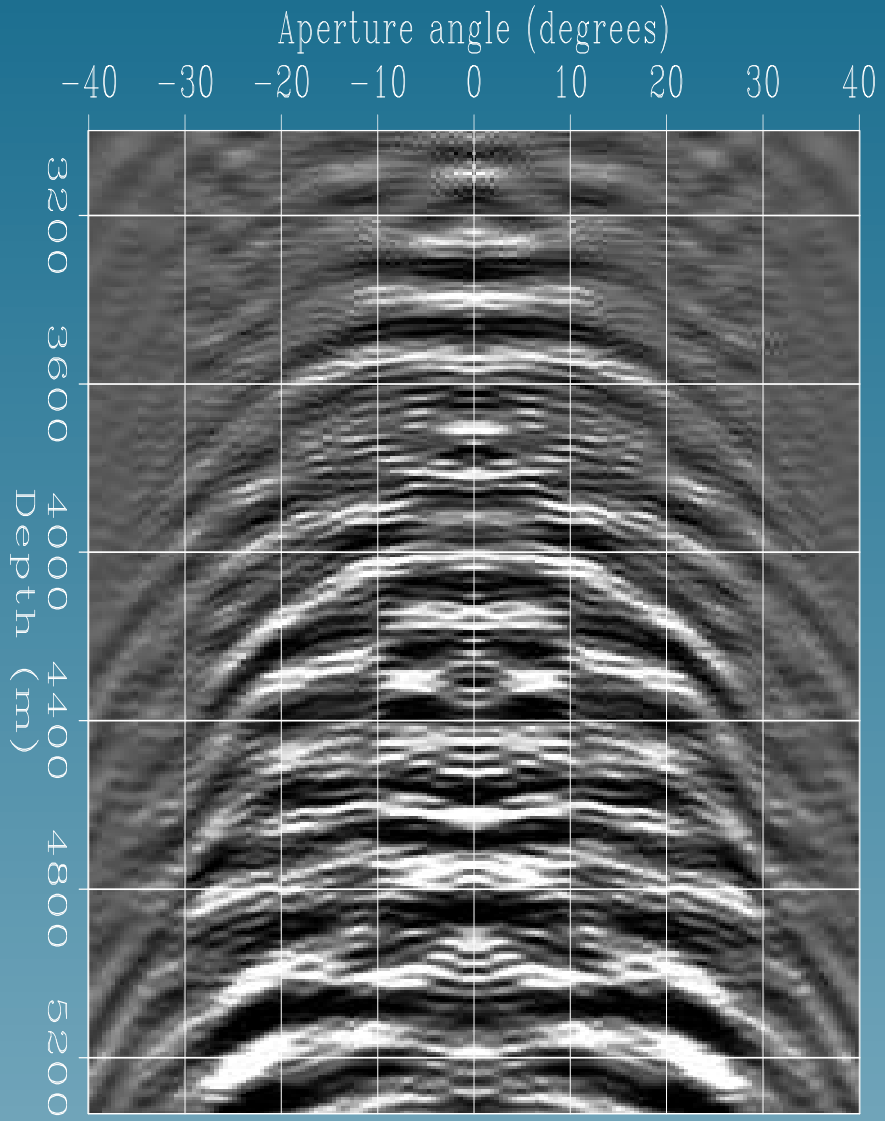
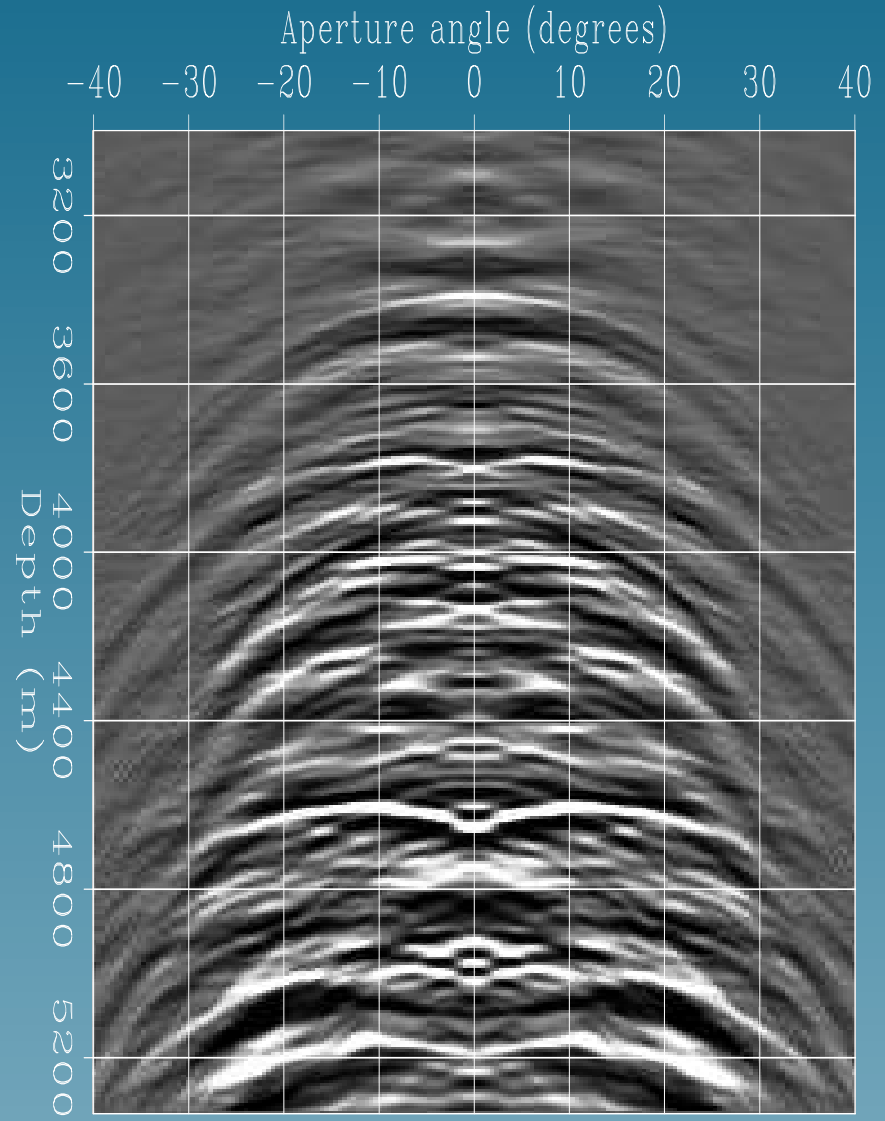
From Last Year



(a) ADCIG 6744 m



(b) ADCIG 6744 m. Multiples 3D transform

Residual Moveout (RMO) Equation

Biondi and Symes (2004) residual moveout equation:

$$\Delta \mathbf{n}_{RMO} = (\rho - 1) \tan^2 \gamma \, z_0 \, \mathbf{n}$$

where:

$\mathbf{n}$: unit normal to the reflector.

ρ: true slowness/migration slowness.

γ: true half-aperture angle.

Aproximations of RMO Equation

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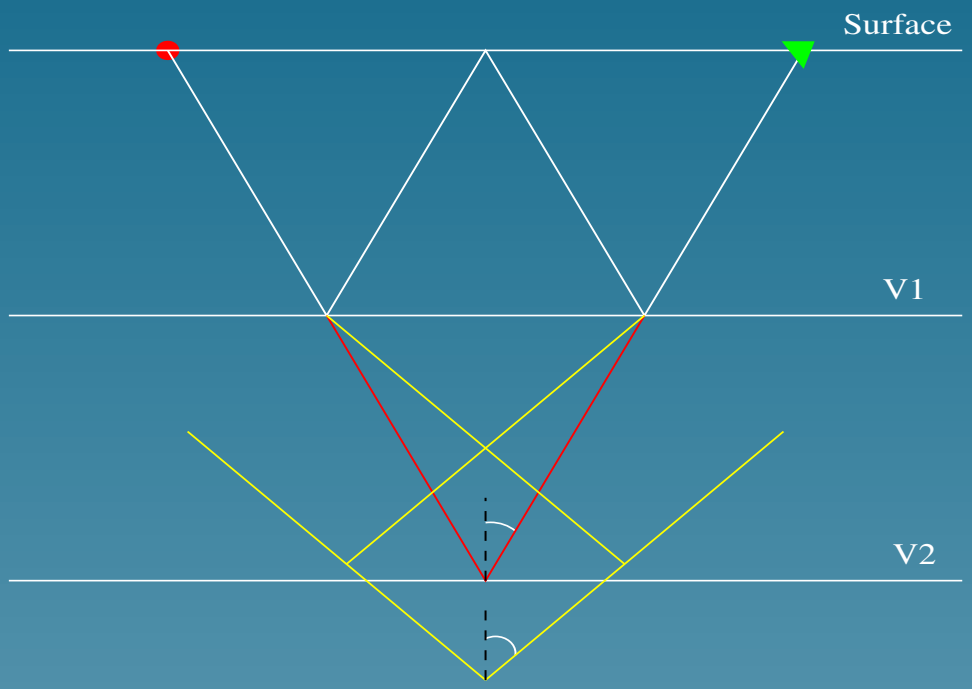
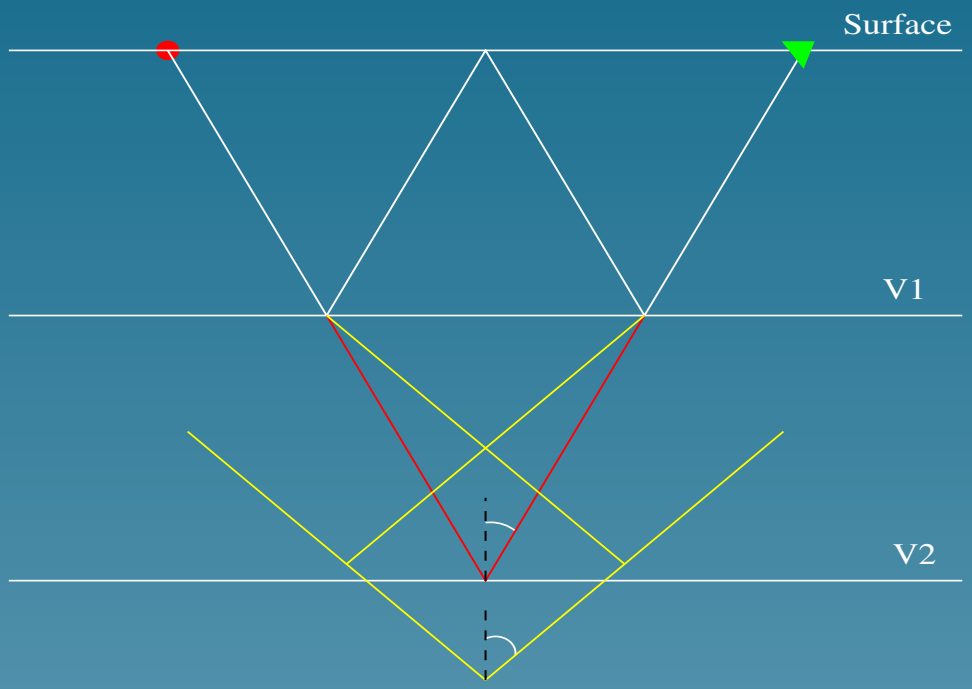
- Flat reflectors
- Rays are stationary: apparent angles taken as equal to true angles.
- ρ is small.

RMO approximation for Multiples



For water-bottom multiples $V_2 >> V_1$ so apparent aperture angle may be significantly different than true aperture angle and ρ is not close to one.

RMO approximation for Multiples



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What about diffracted multiples?

Motivation

- Understand the residual moveout of multiples in image space when migrated with the velocity of the primaries.

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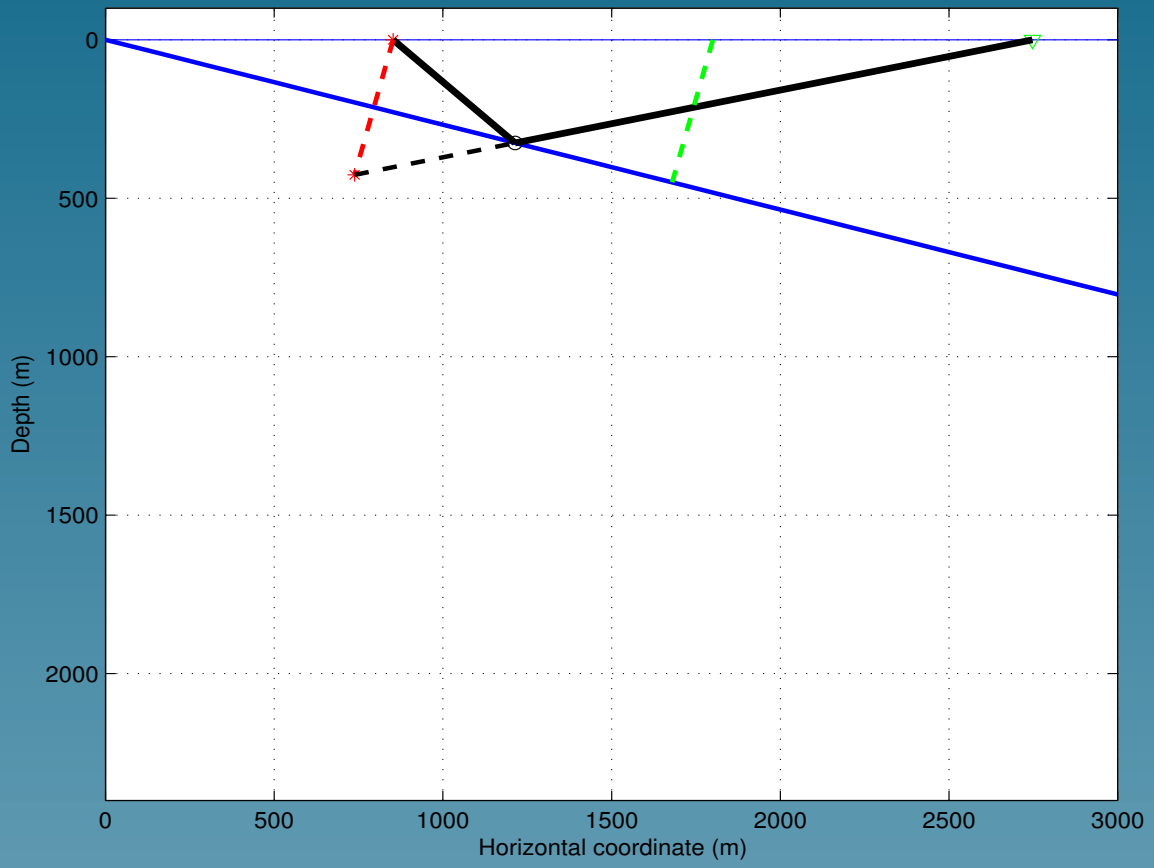
- Understand the residual moveout of multiples in image space when migrated with the velocity of the primaries.
- Use the residual moveout to design the appropriate Radon transform to attenuate the multiples in the image space.

Raypath of Primary

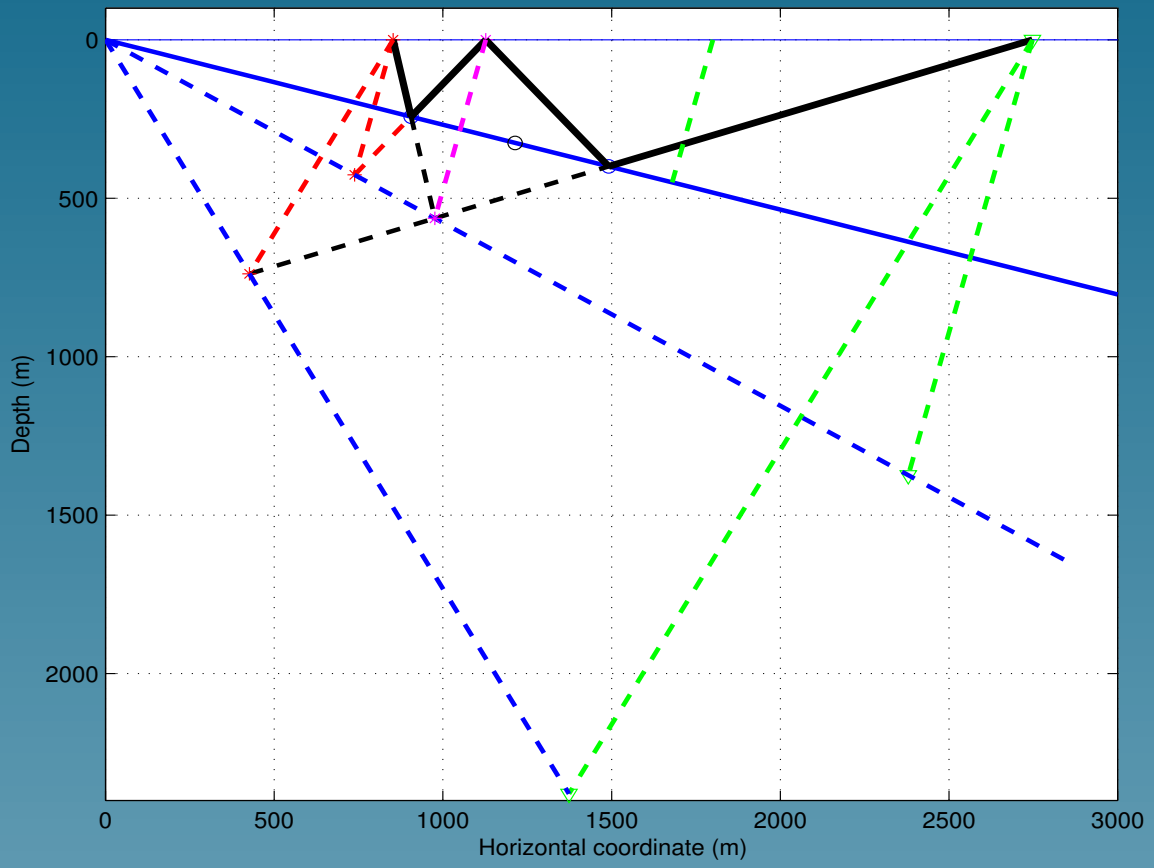


$$t_p(h_D) = \sqrt{t_p^2(0) + \left(\frac{2h_D}{V_{NMO}}\right)^2} \qquad V_{NMO} = \frac{V}{\cos\varphi}$$

h_D: half-offset

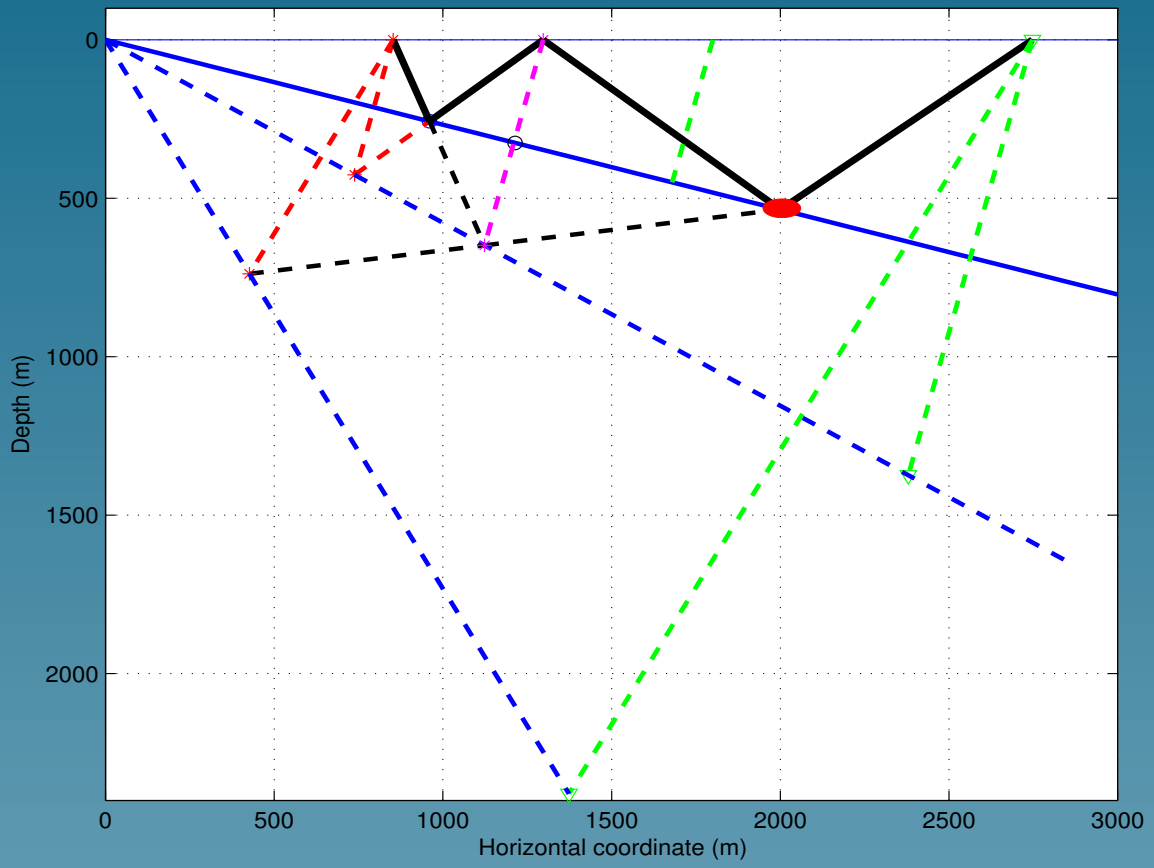
φ: reflector dip

Raypath of Water-bottom Multiple



$$t_m(h_D) = \sqrt{t_m^2(0) + \left(\frac{2h_D}{\hat{V}_{NMO}}\right)^2} \qquad \hat{V}_{NMO} = \frac{V}{\cos(2\varphi)}$$

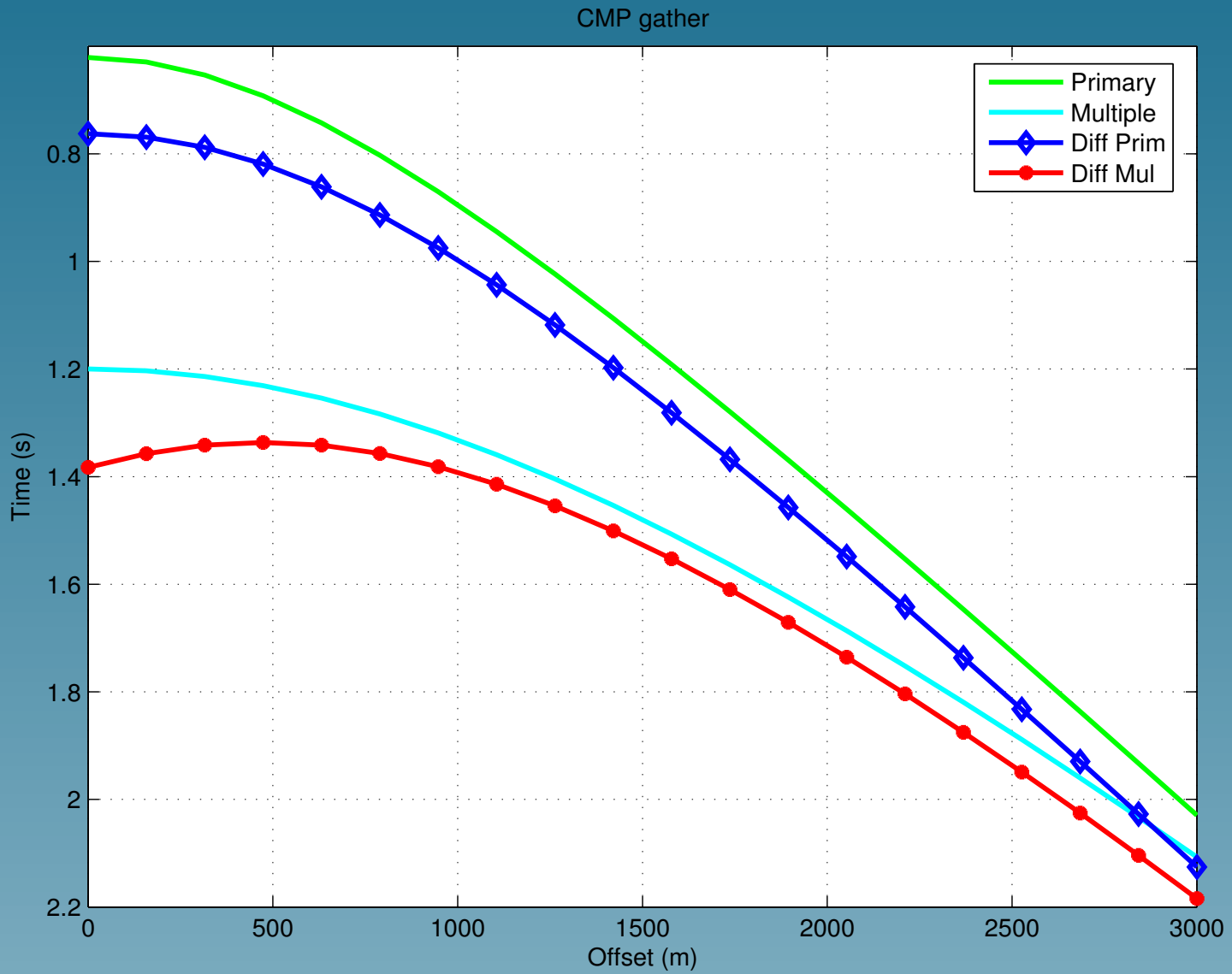
Raypath of Diffracted Multiple



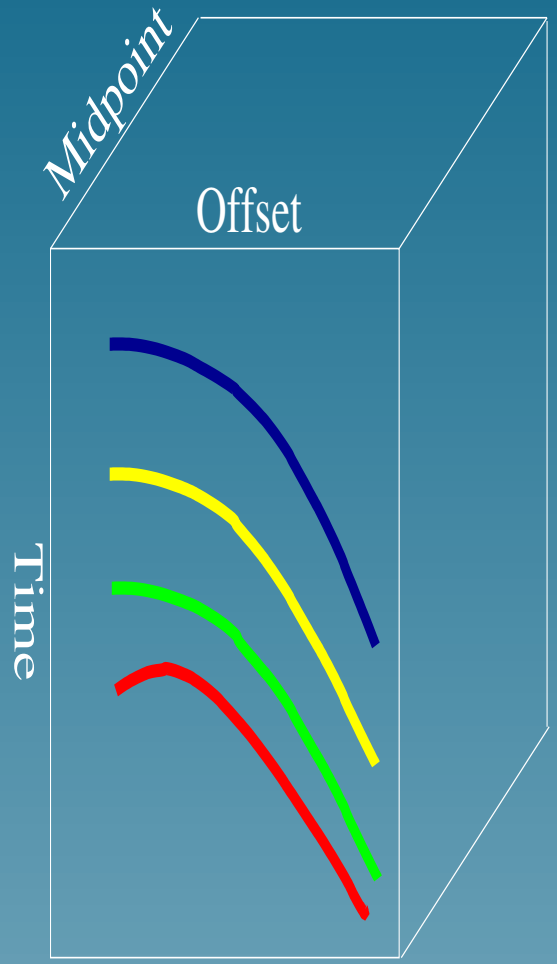
$$t_m(h_D) = \frac{2(Z_D - h_D \sin\varphi)\cos\varphi}{\cos(\beta_s + 3\varphi)} + \frac{z_d}{V\cos\beta_r}$$

$\beta_s,\ \beta_r$: take-off angles $\qquad$ z_d: diffractor position

Moveouts on a CMP Gather



Schematic of Moveout of Multiples



Data space

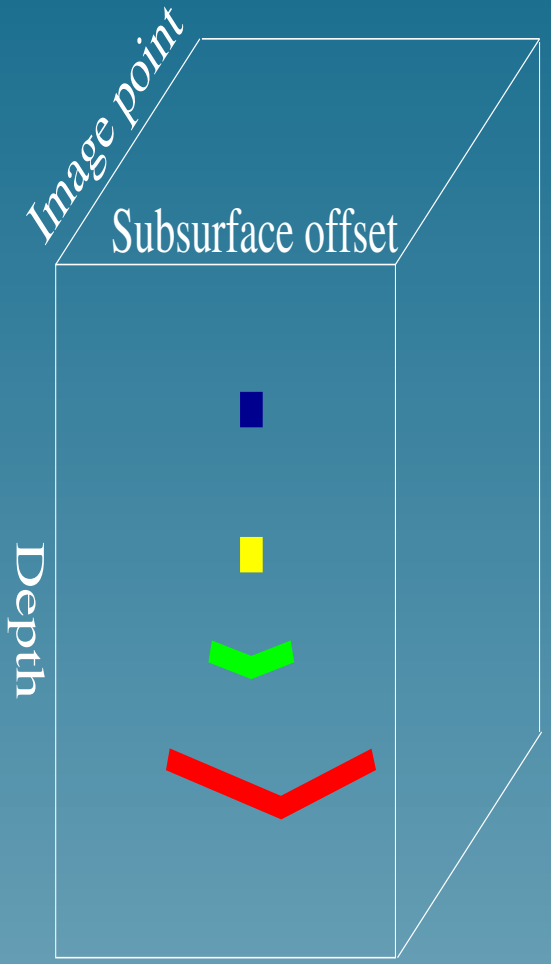


Image space

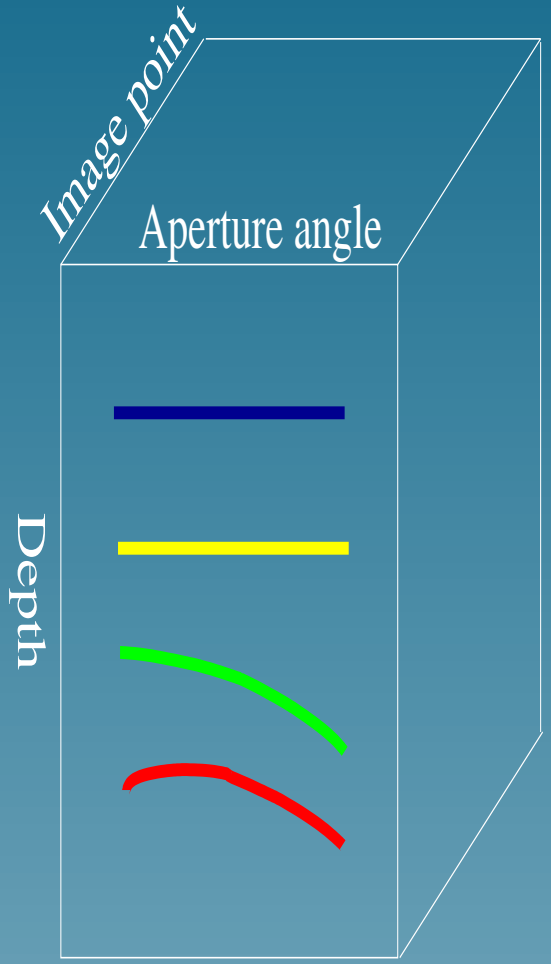


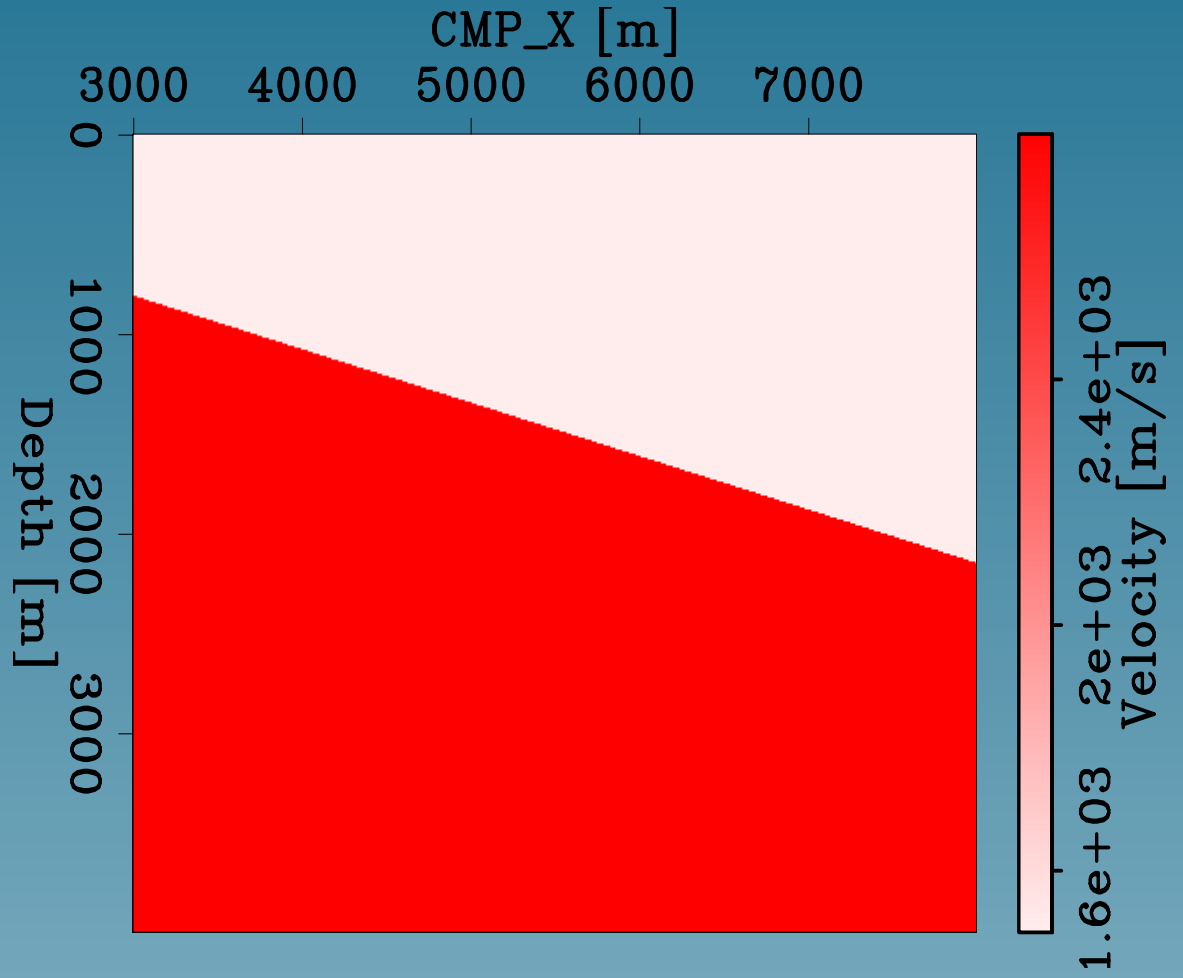
Image space

Example with 2-D Synthetic Dataset

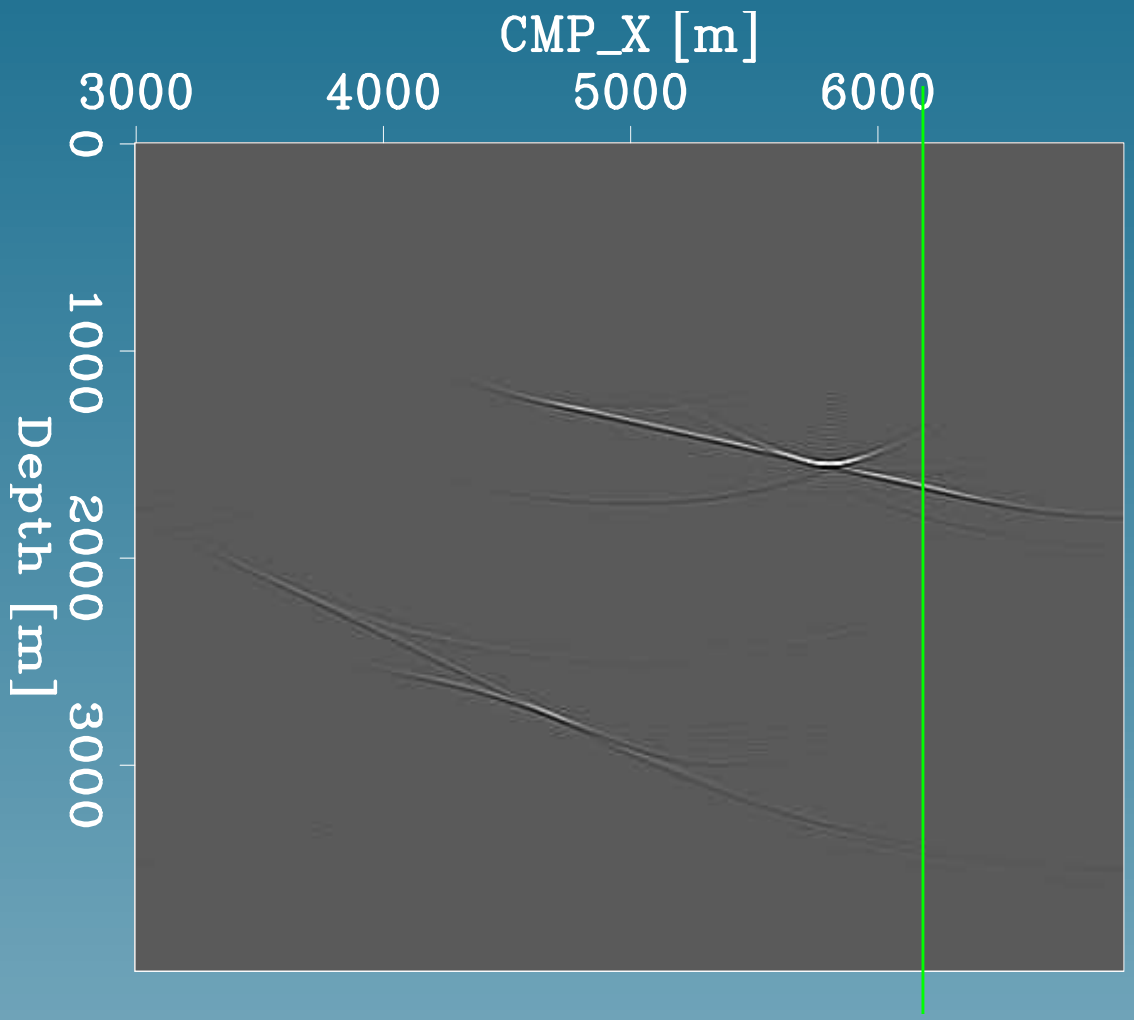
200 cmps
100 traces/cmp
0-2970 m offsets
20 m cmp interval

4 events:

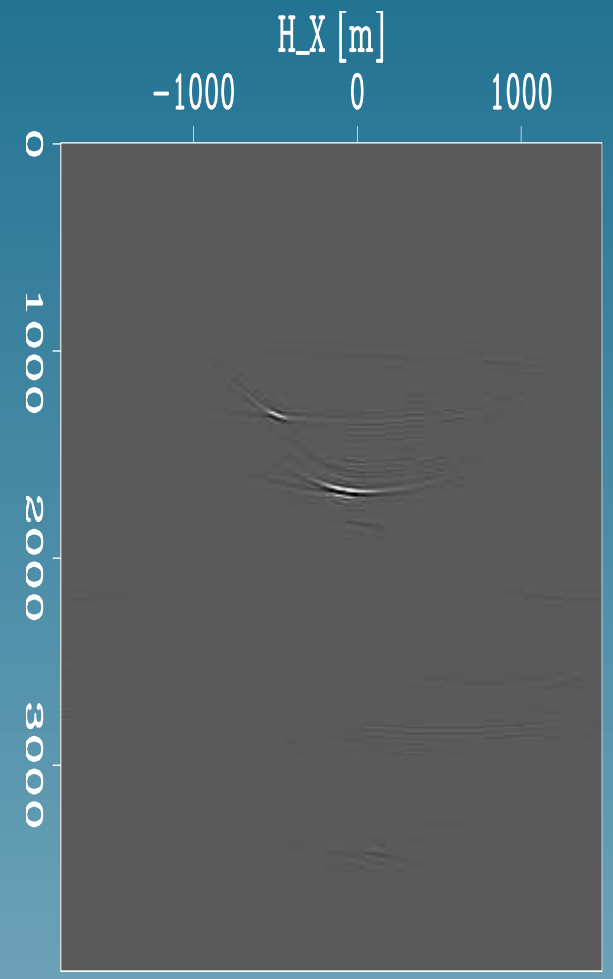
- ⋆ primary
- ⋆ wb multiple
- ⋆ primary diffraction
- ⋆ diffracted multiple



Primary. Two Velocities

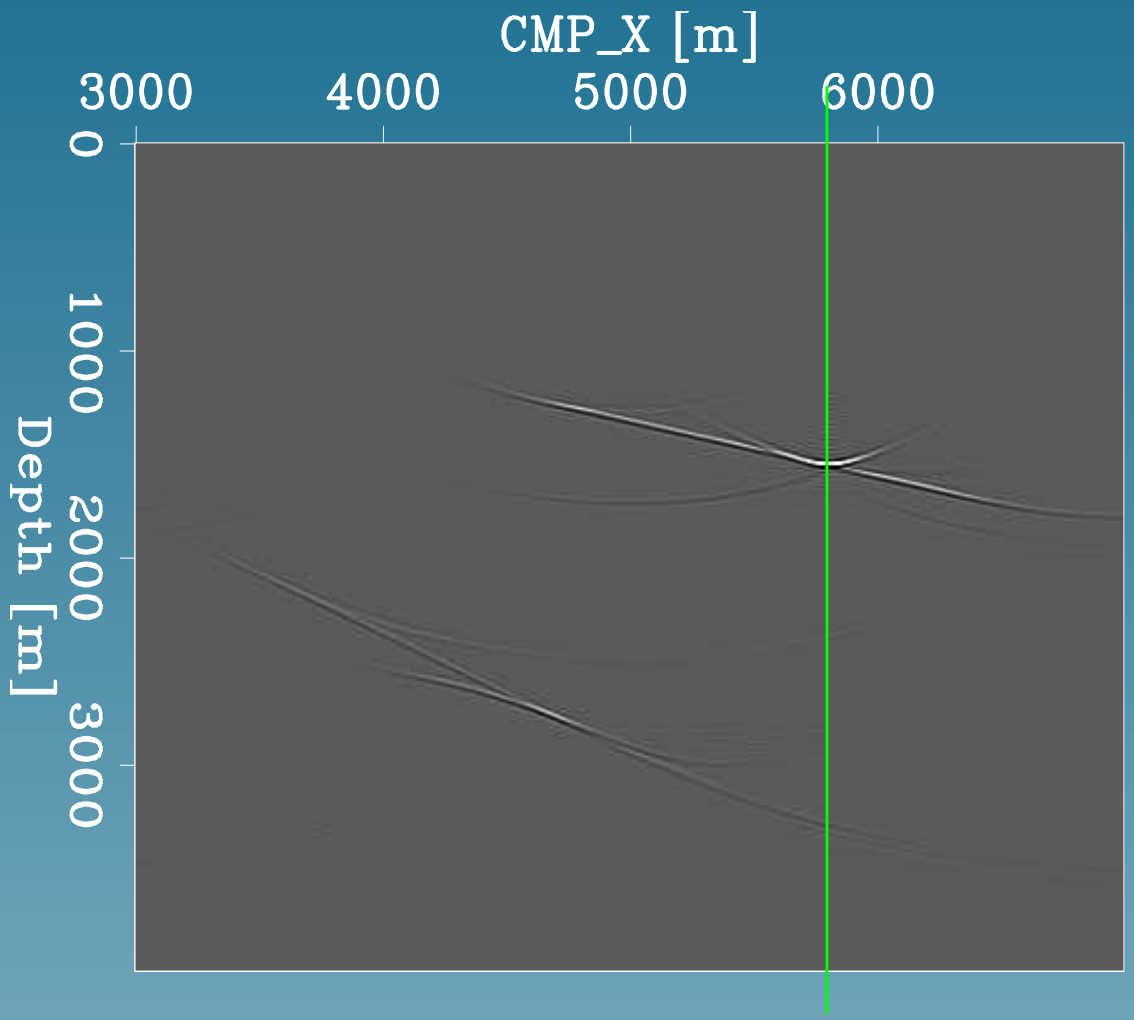


Zero subsurface-offset section

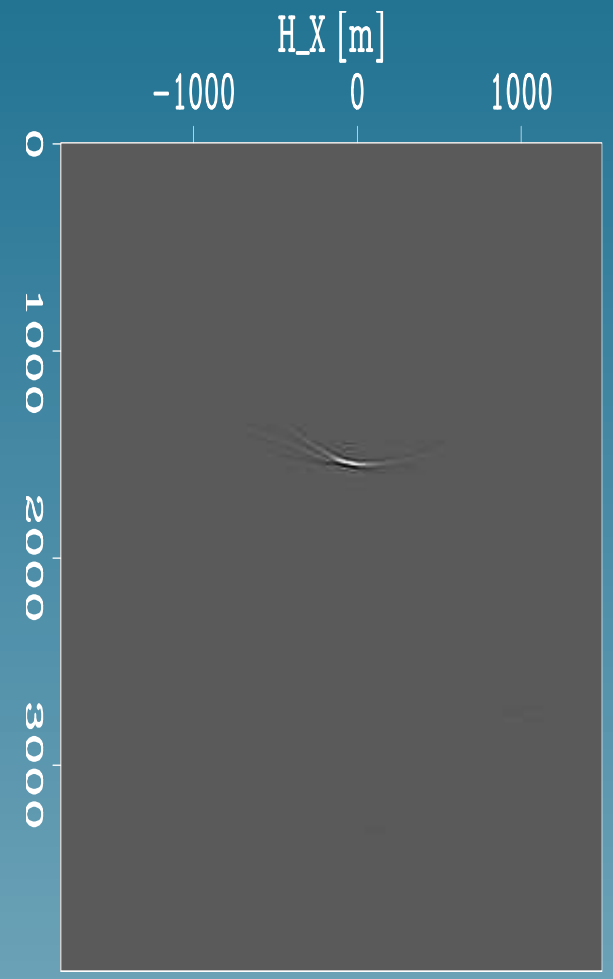


SOCIG (x=6280)

Diffraction. Two Velocities

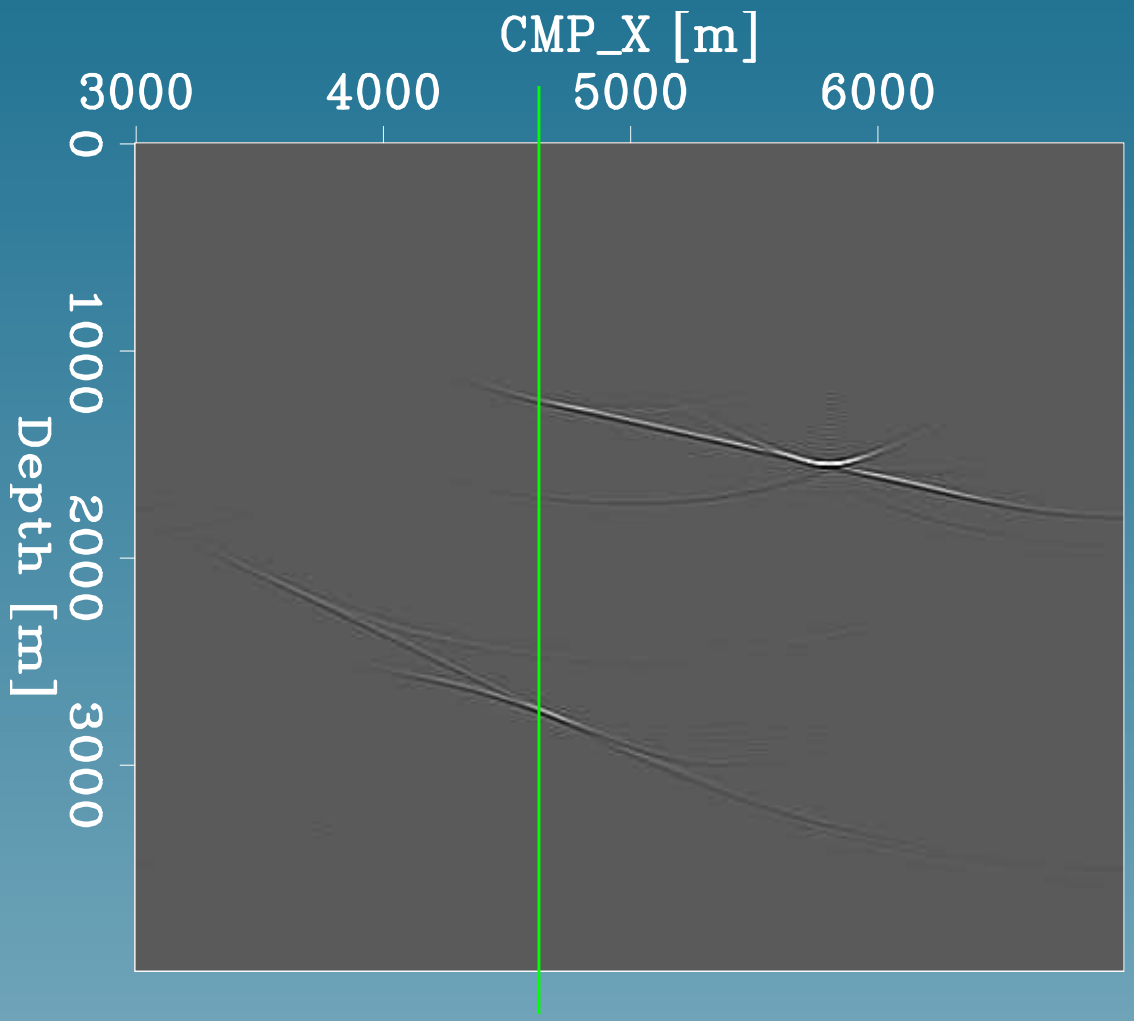


Zero subsurface-offset section

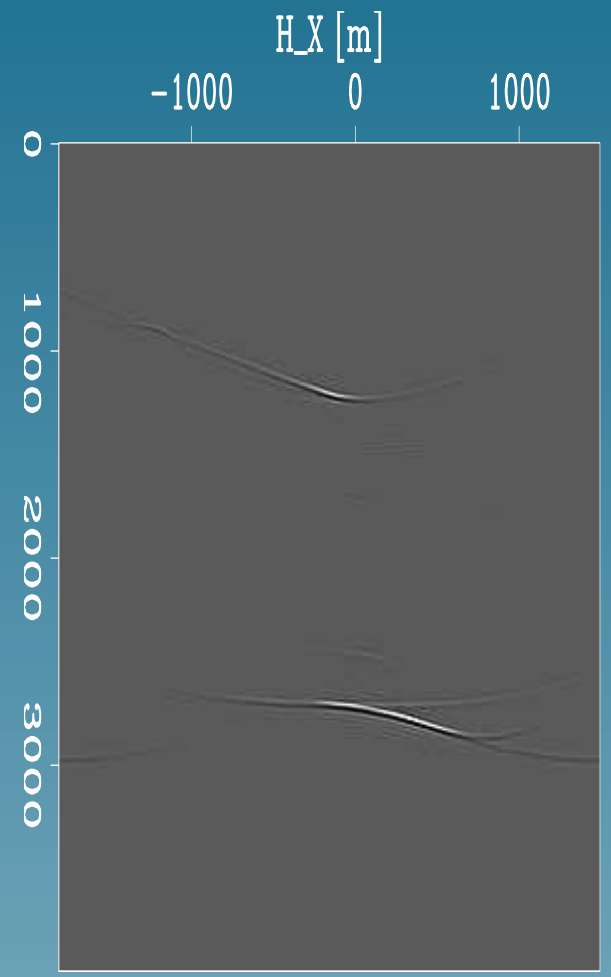


SOCIG (x=5800)

Diffracted Multiple. Two Velocities

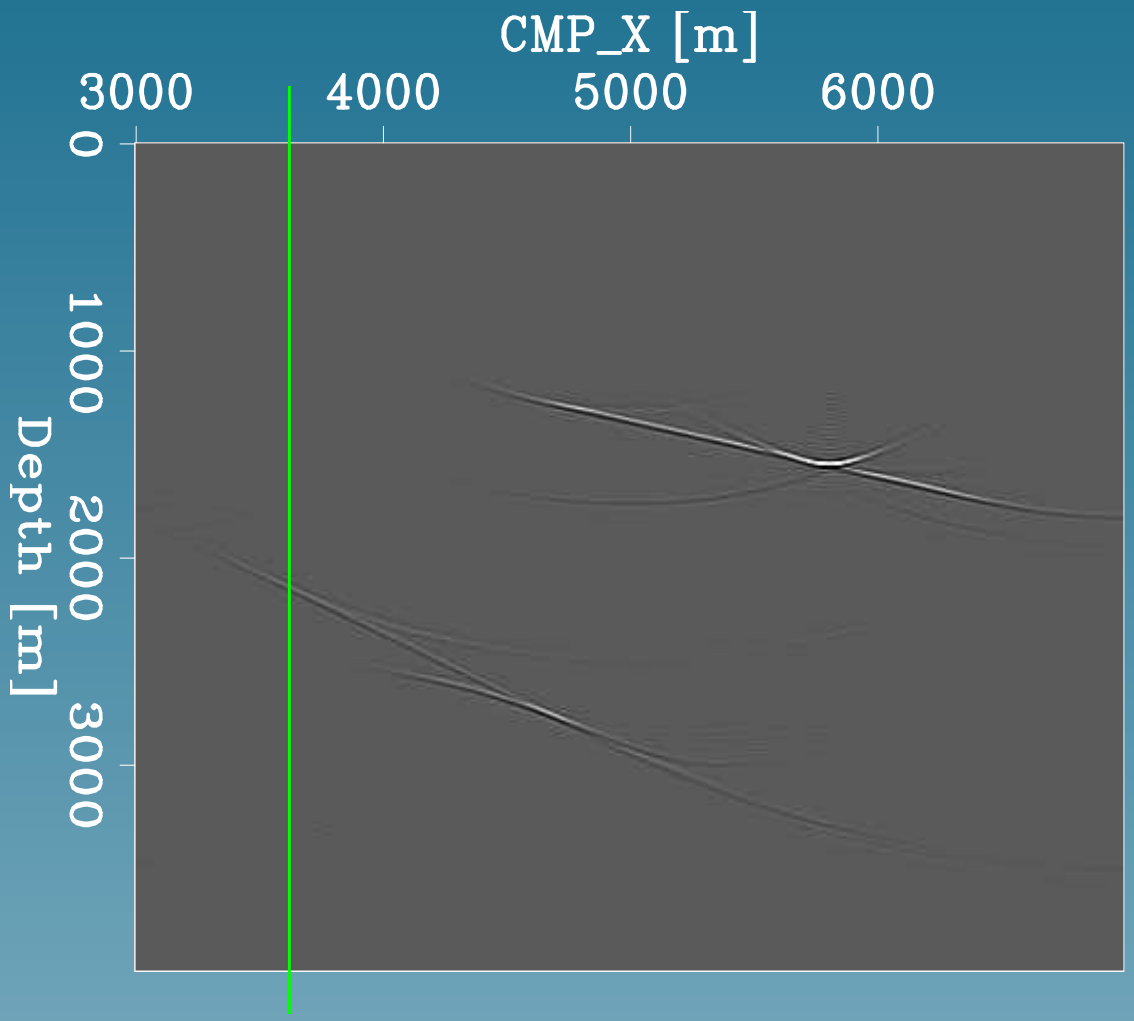


Zero subsurface-offset section

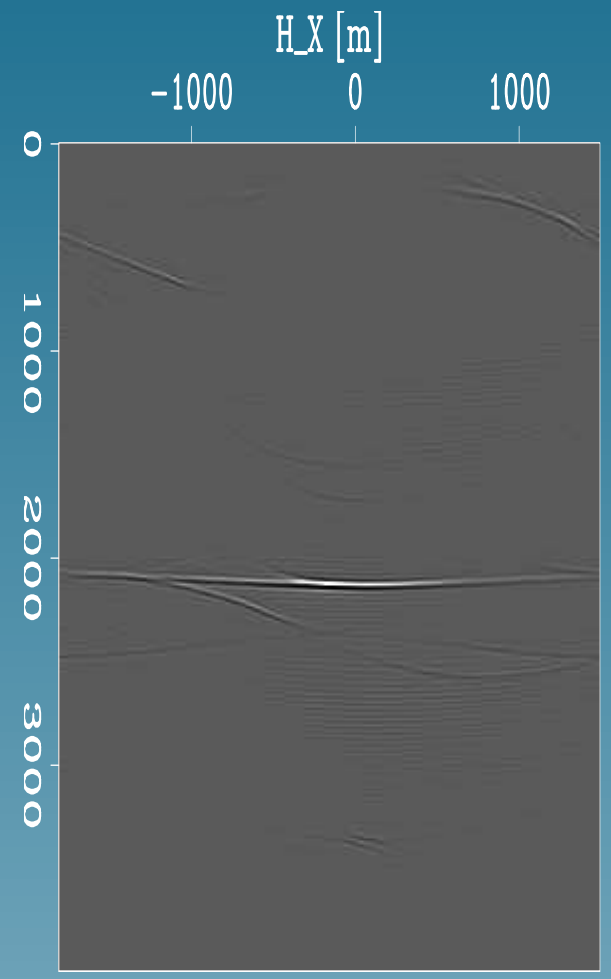


SOCIG (x=4600)

WB Multiple. Two Velocities

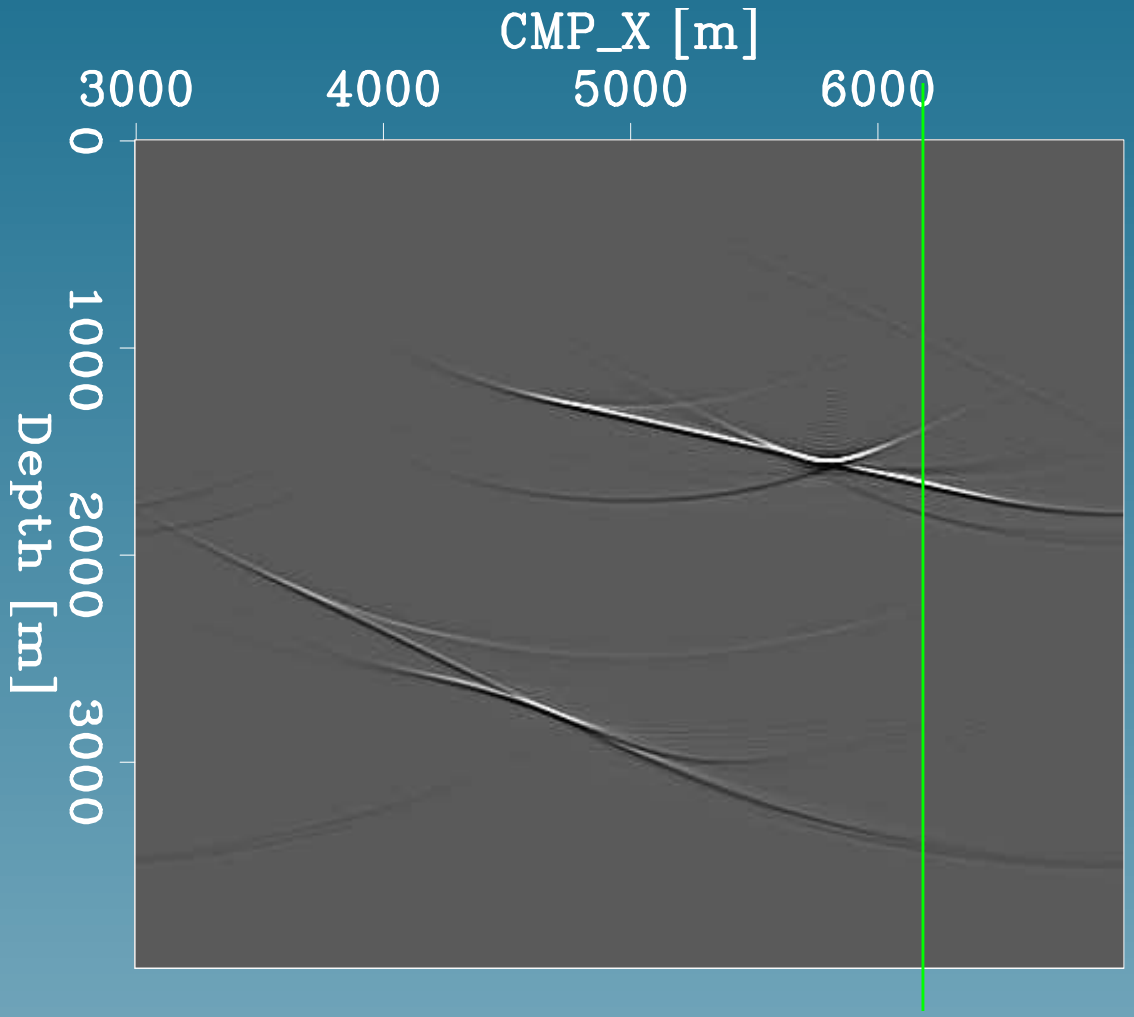


Zero subsurface-offset section

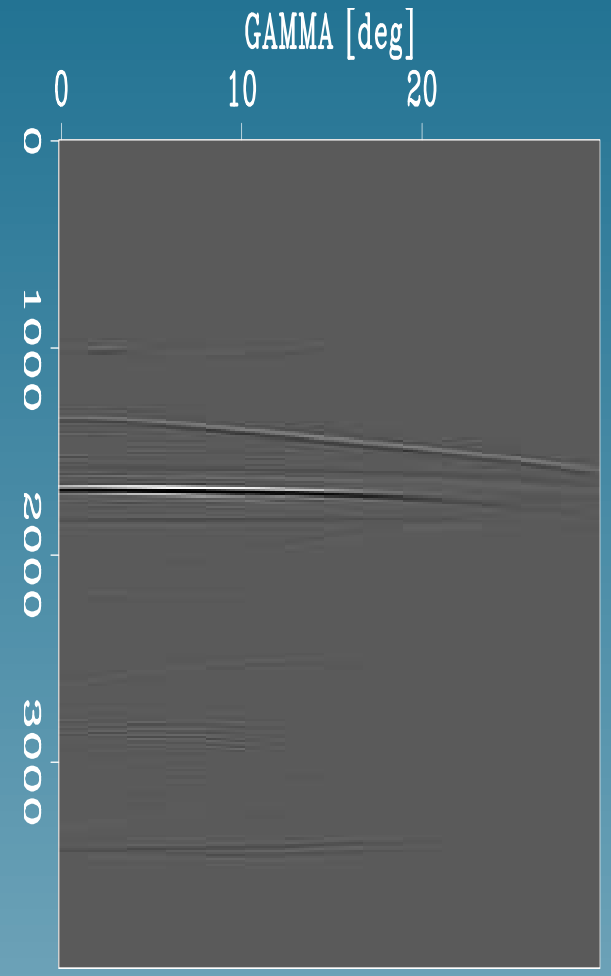


SOCIG (x=3600)

Primary. Two Velocities

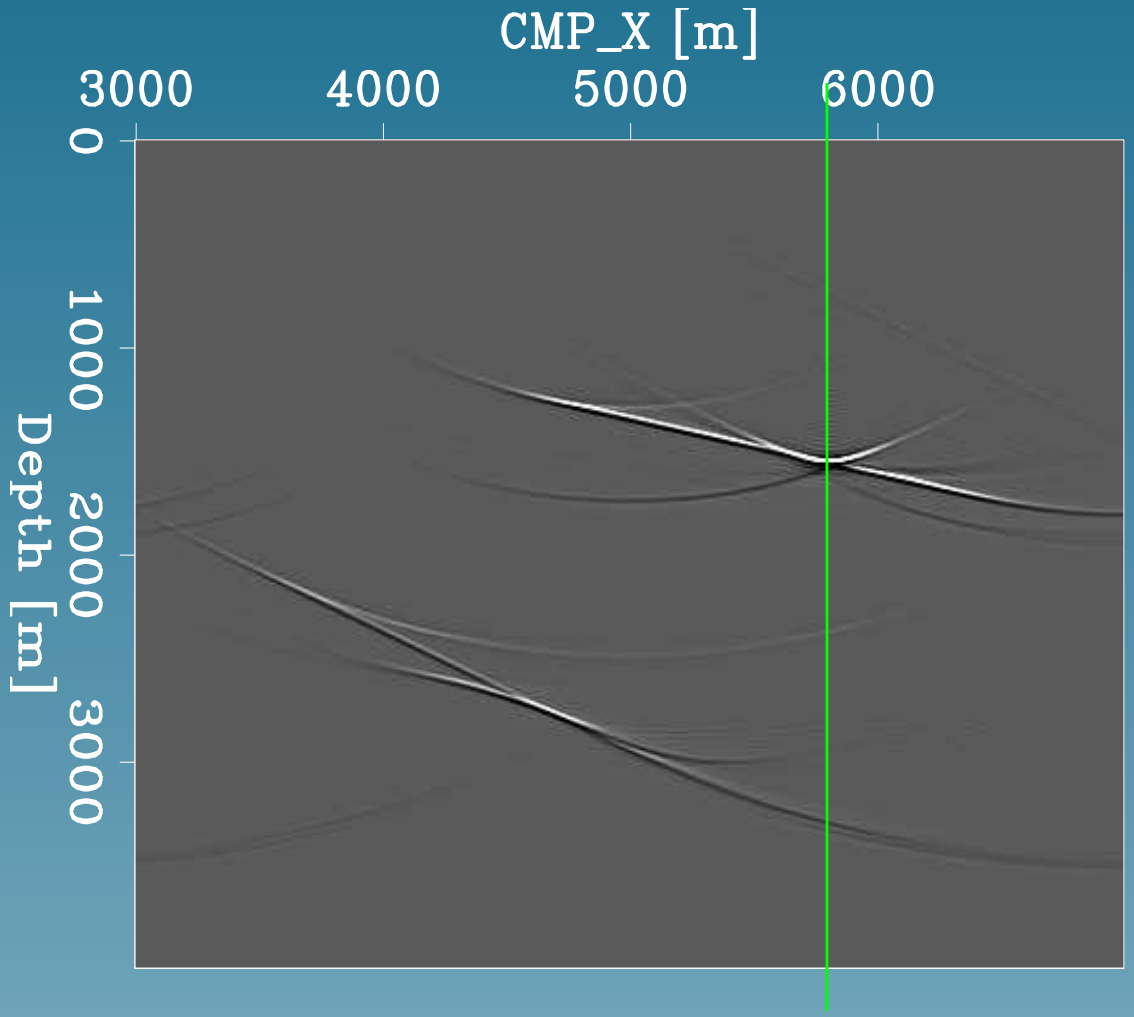


Angle stack

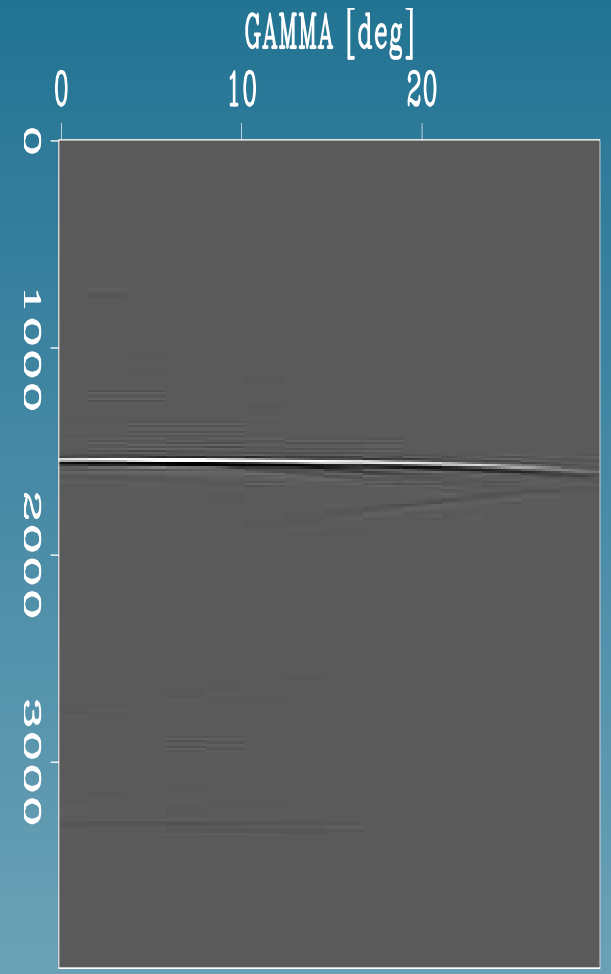


ADCIG (x=6280)

Diffraction. Two Velocities



Angle stack



ADCIG (x=5800)

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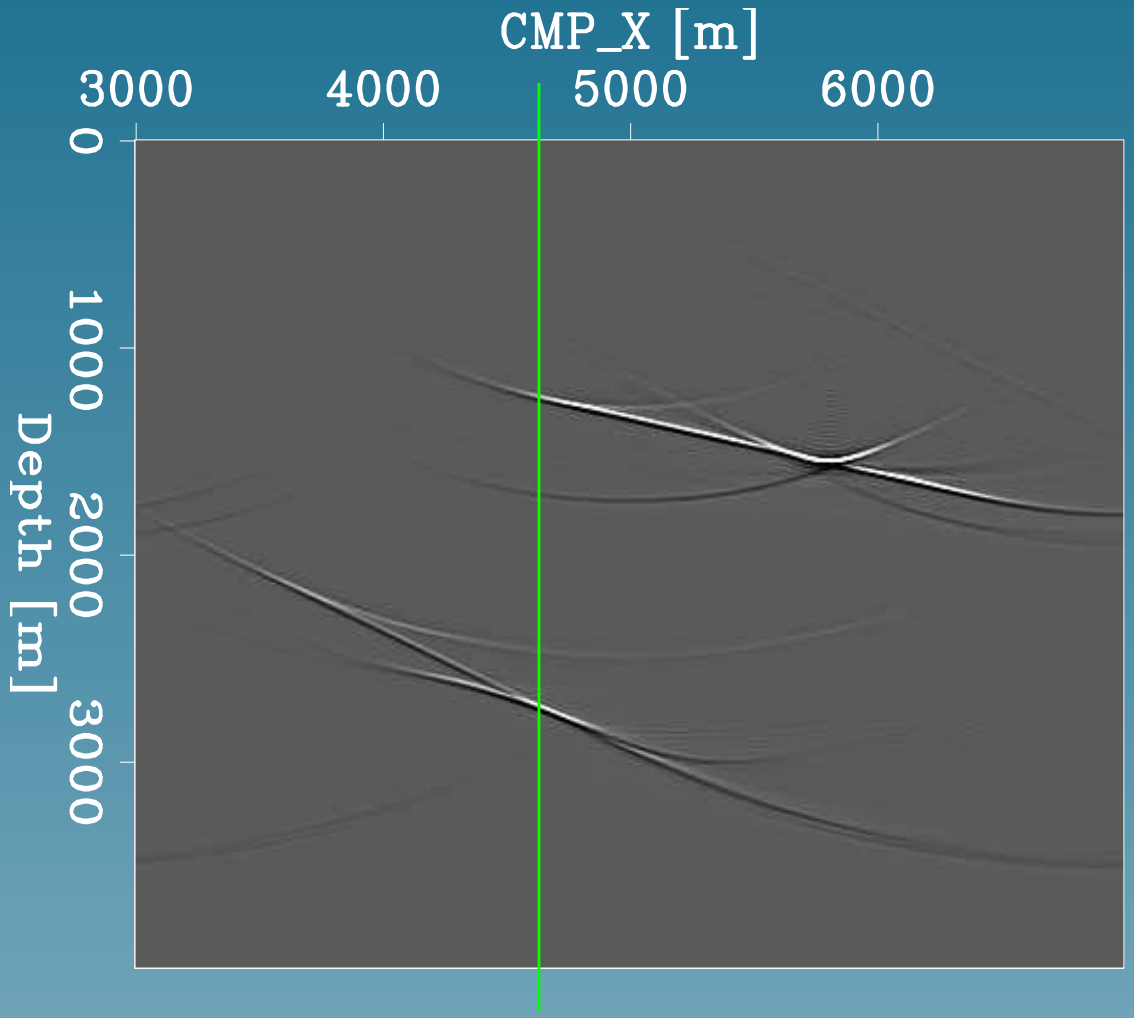
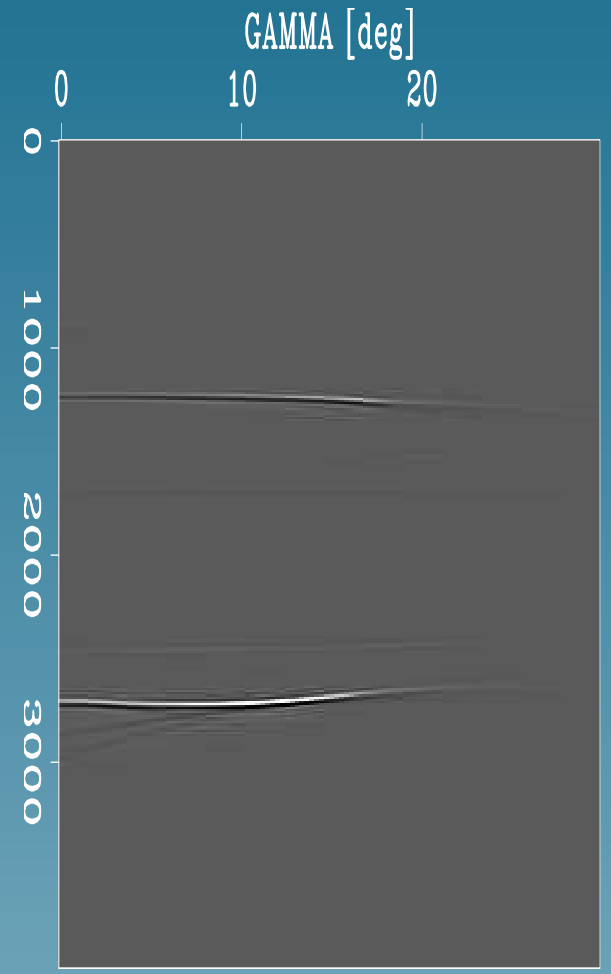


Angle stack



ADCIG (x=4600)

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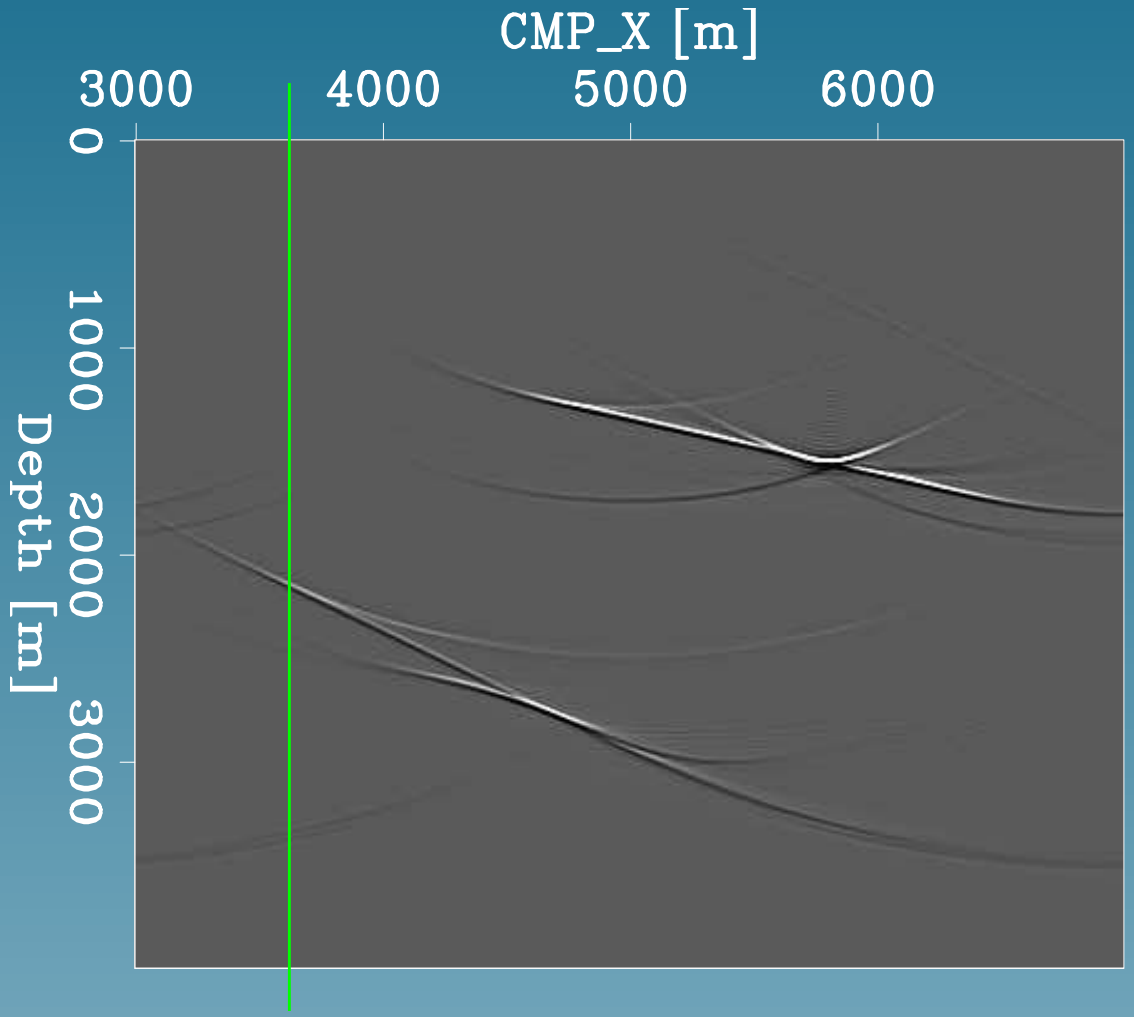
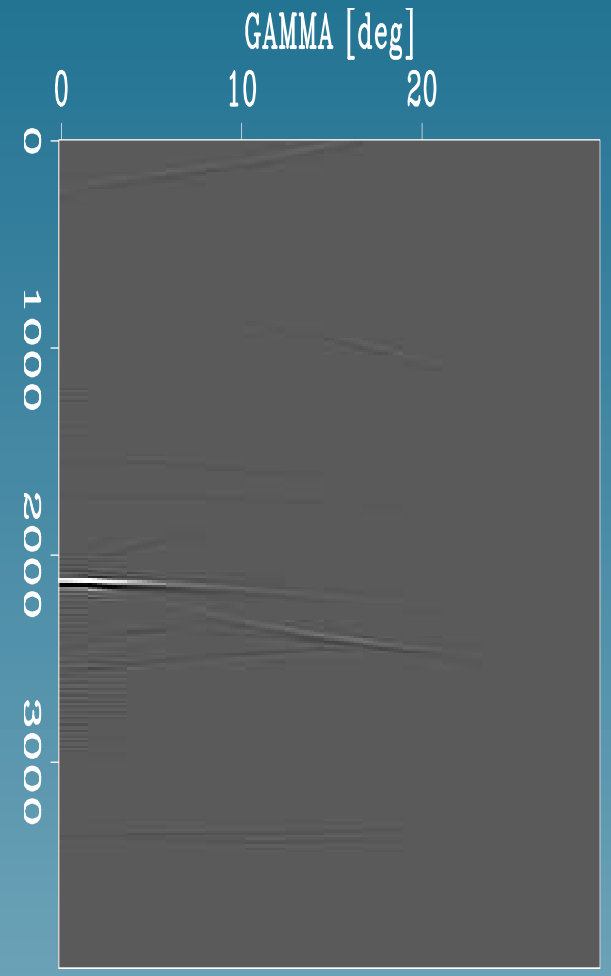
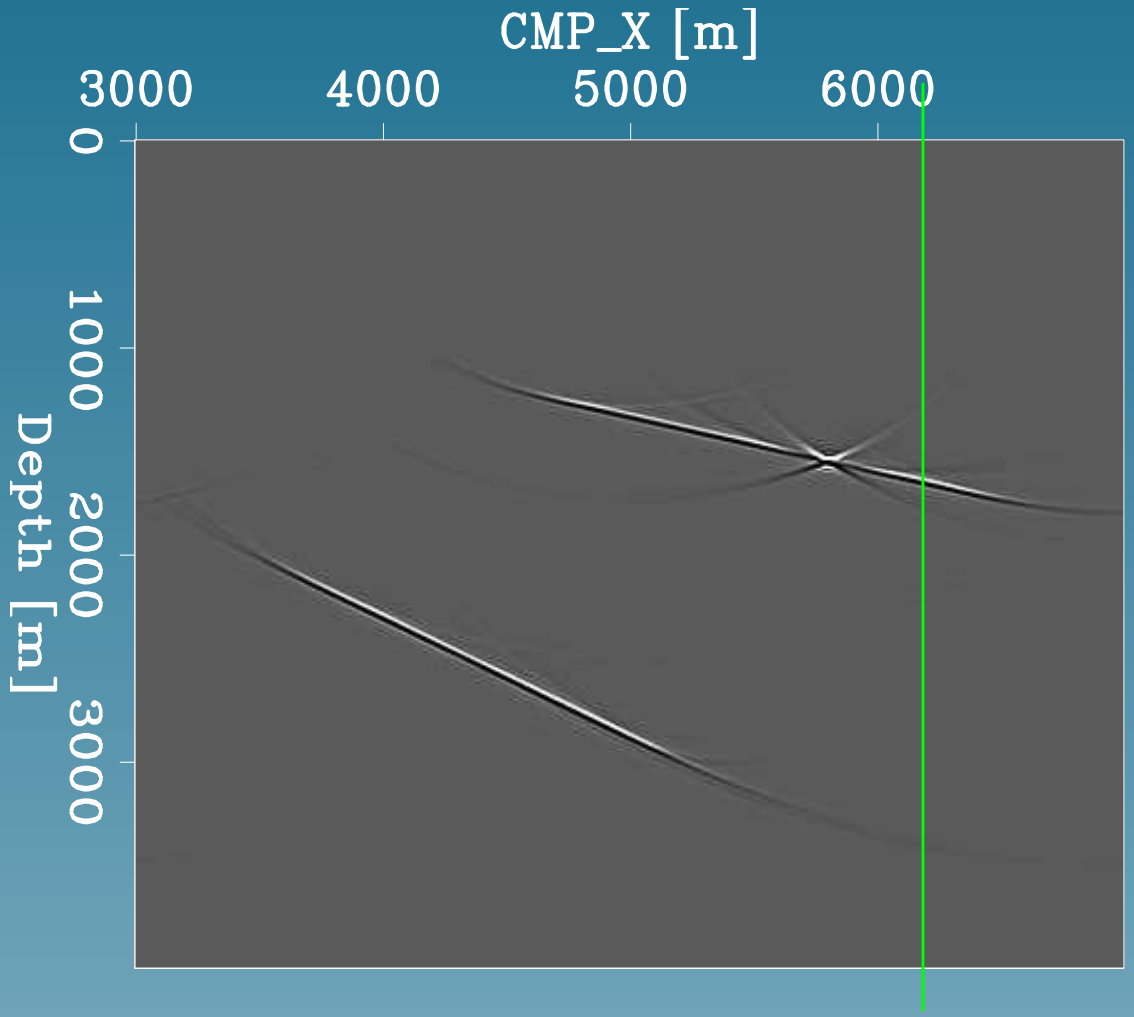


Angle stack

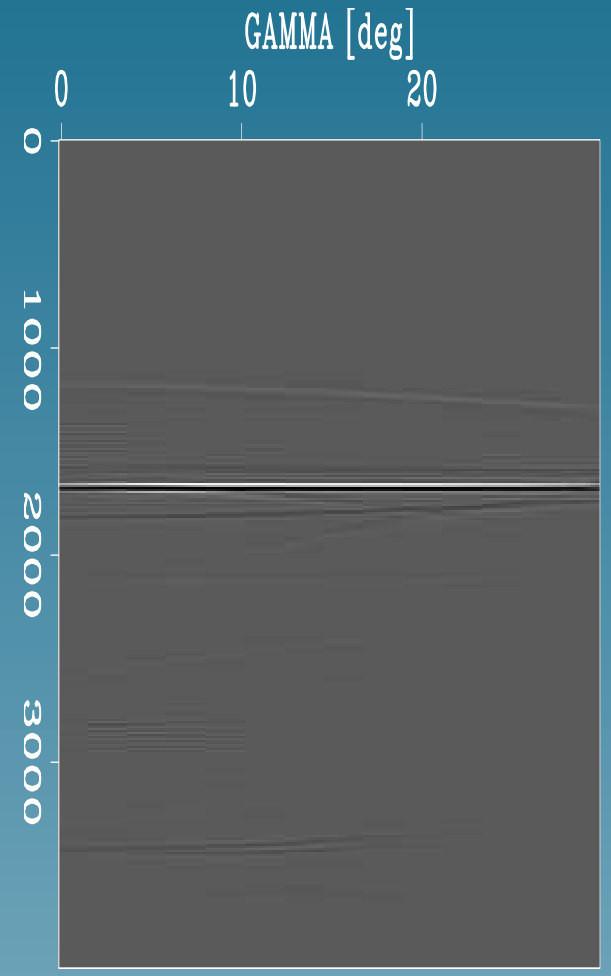


ADCIG (x=3600)

Primary. One Velocity

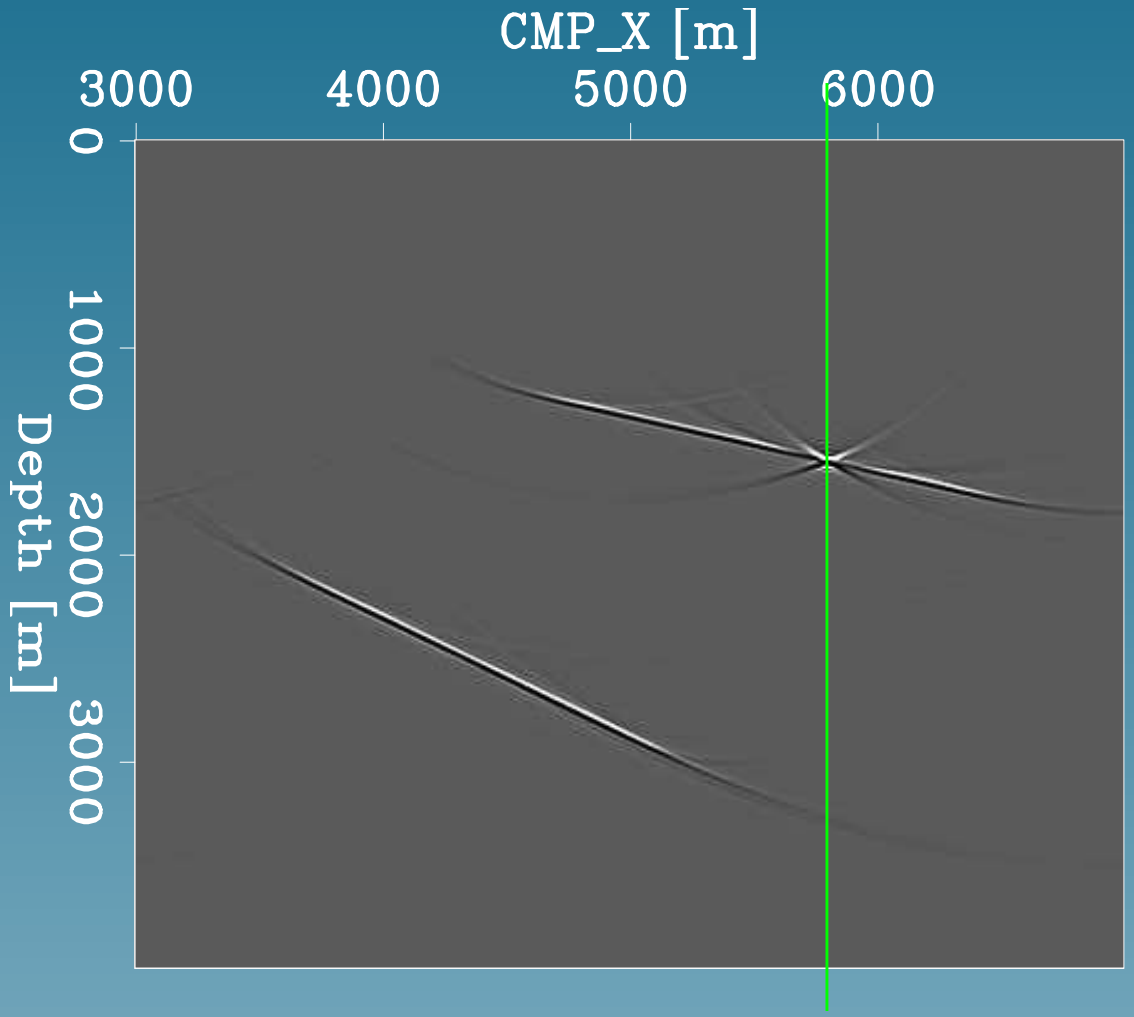


Angle stack

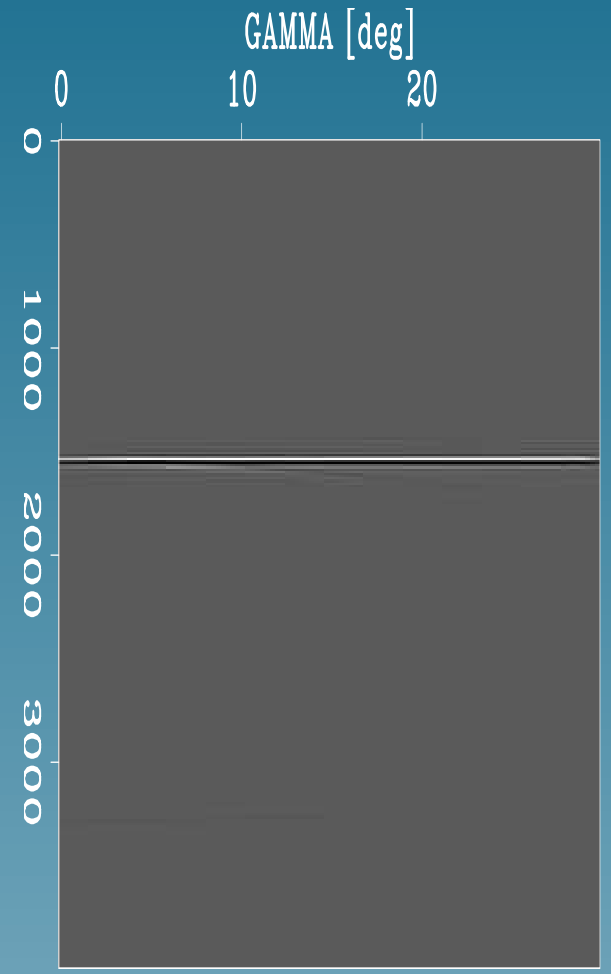


ADCIG (x=6280)

Diffraction. One Velocity

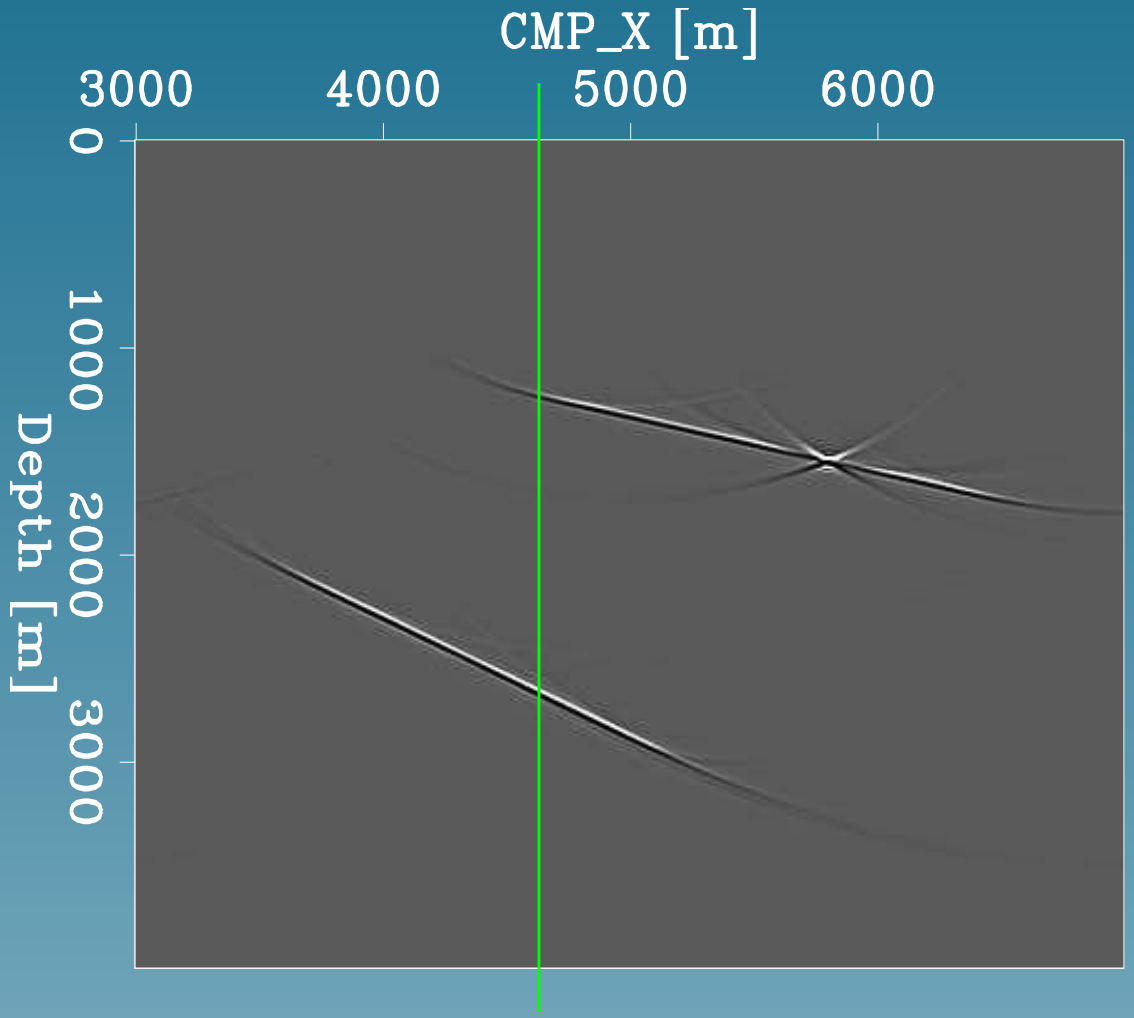


Angle stack

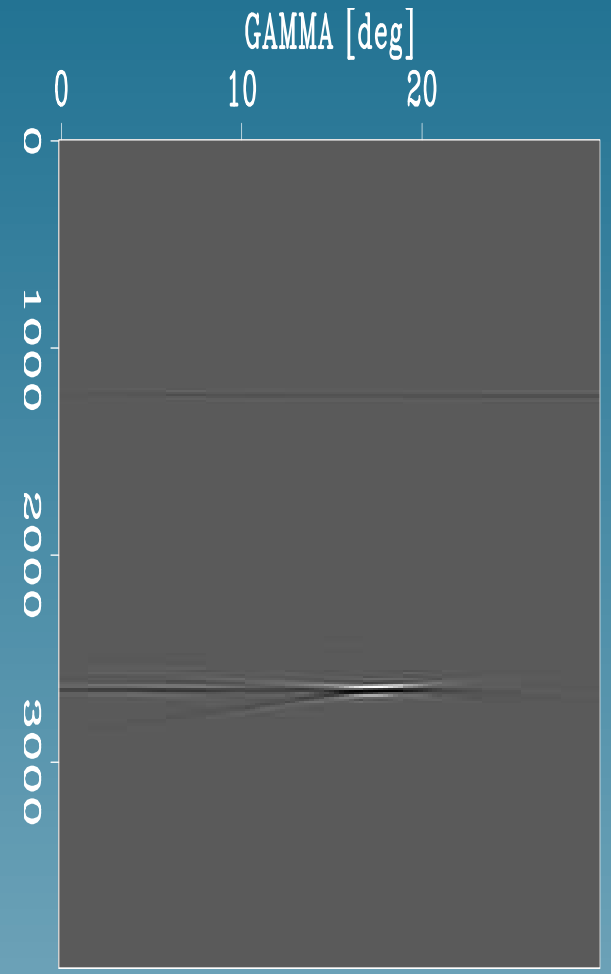


ADCIG (x=5800)

Diffracted Multiple. One Velocity

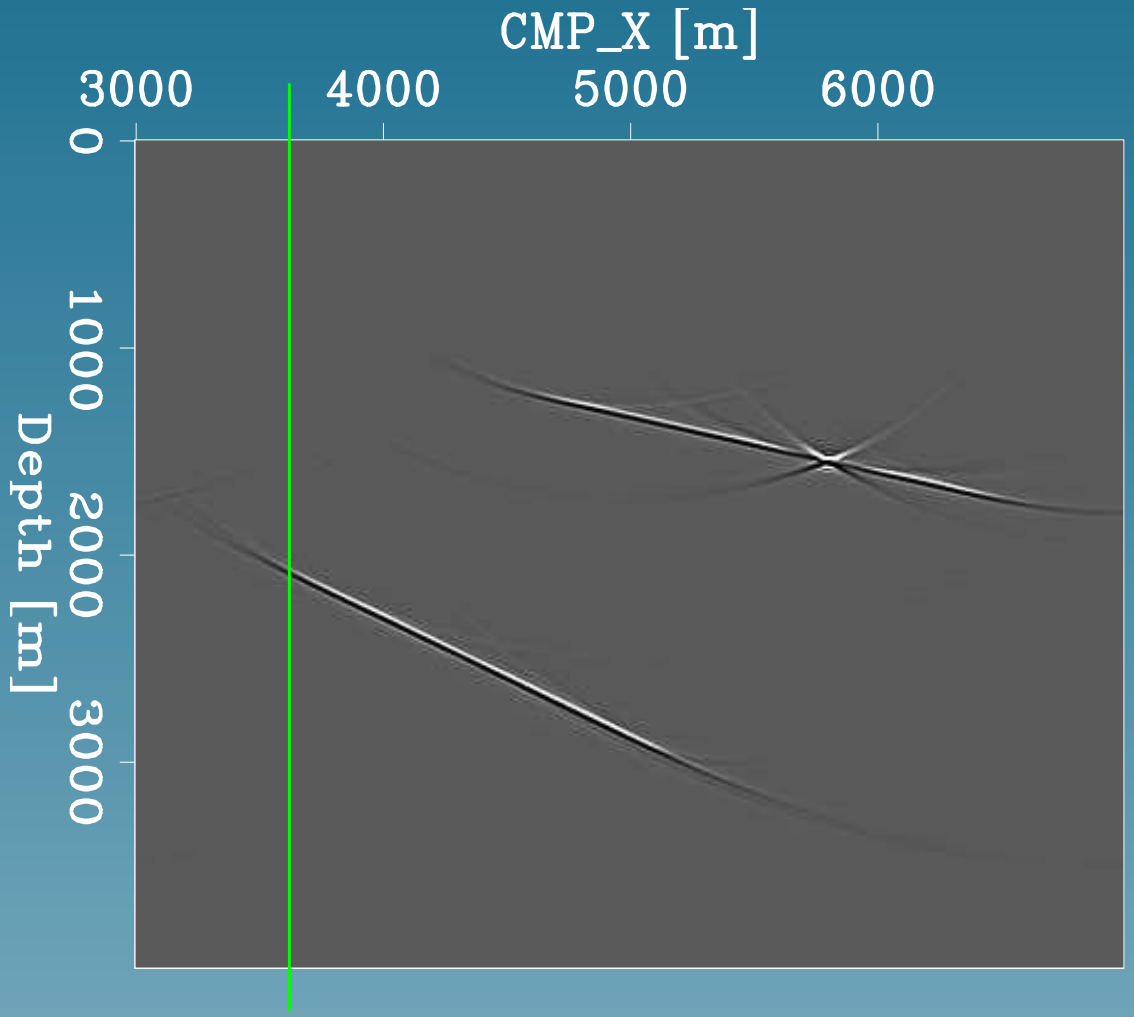


Angle stack

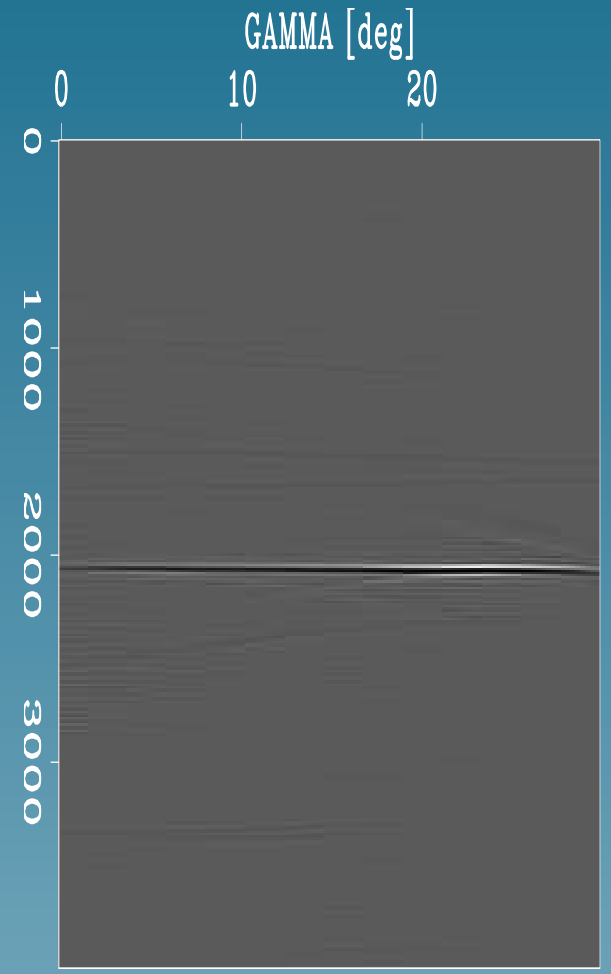


ADCIG (x=4600)

WB Multiple. One Velocity

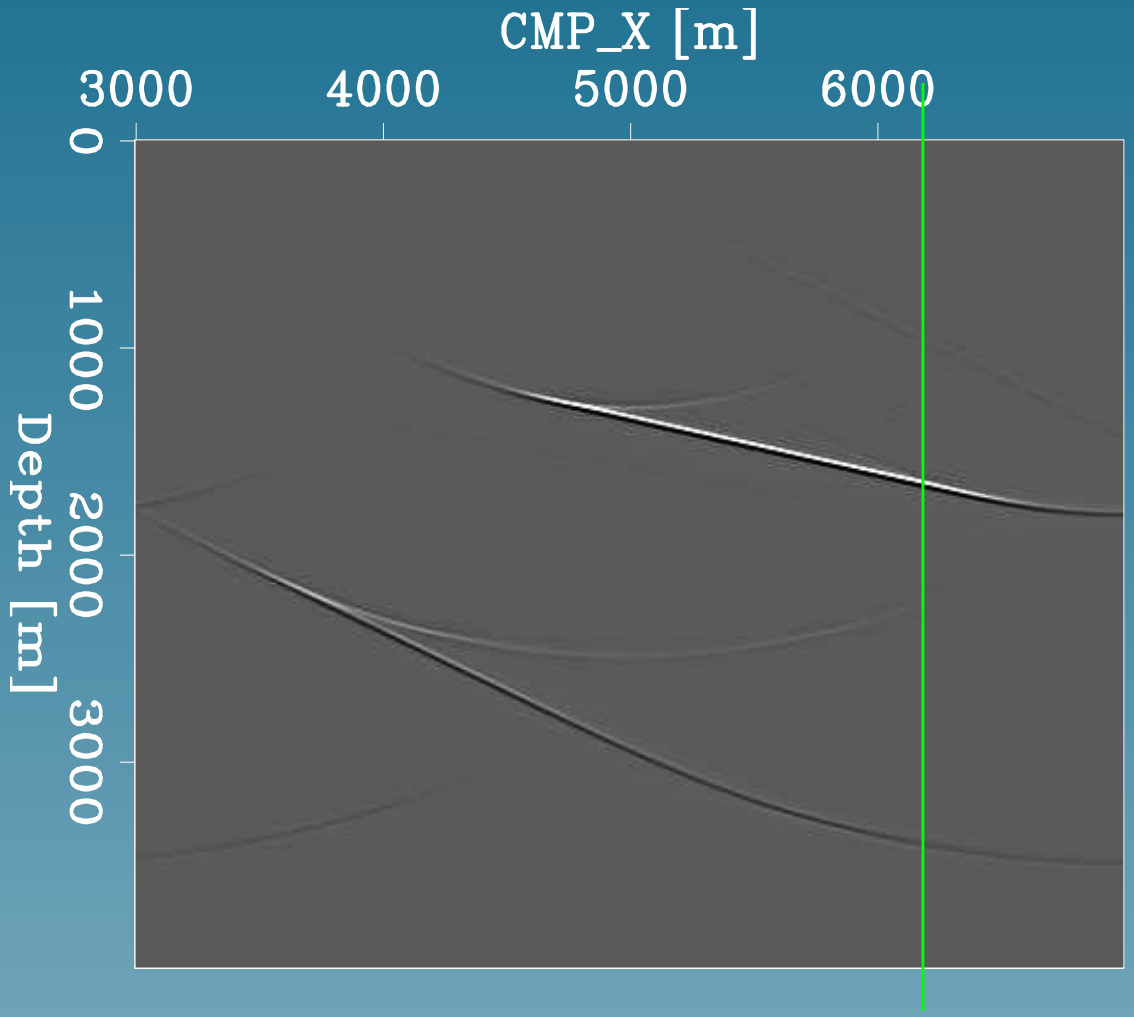


Angle stack

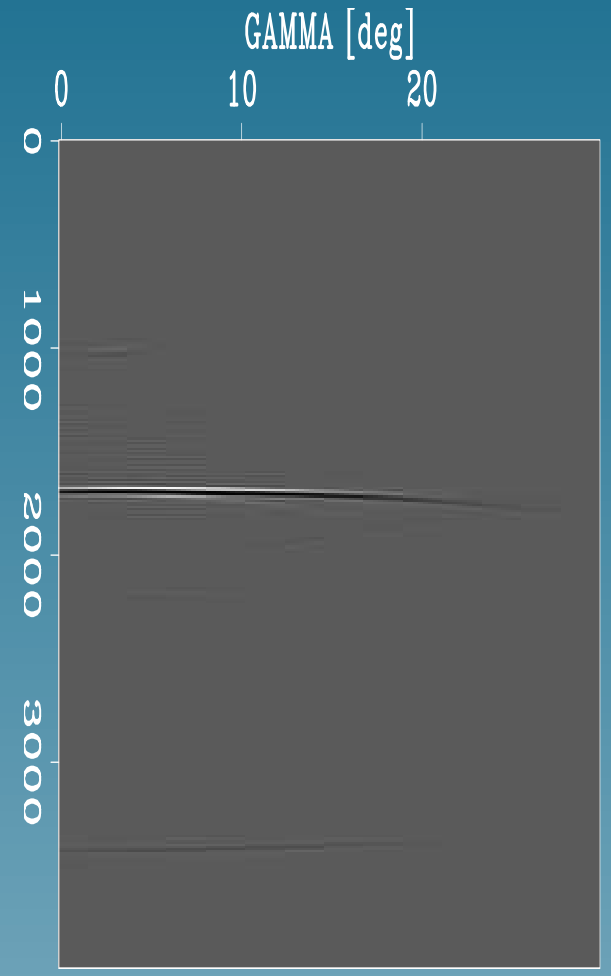


ADCIG (x=3600)

Primary. No Diffraction. Two Velocities

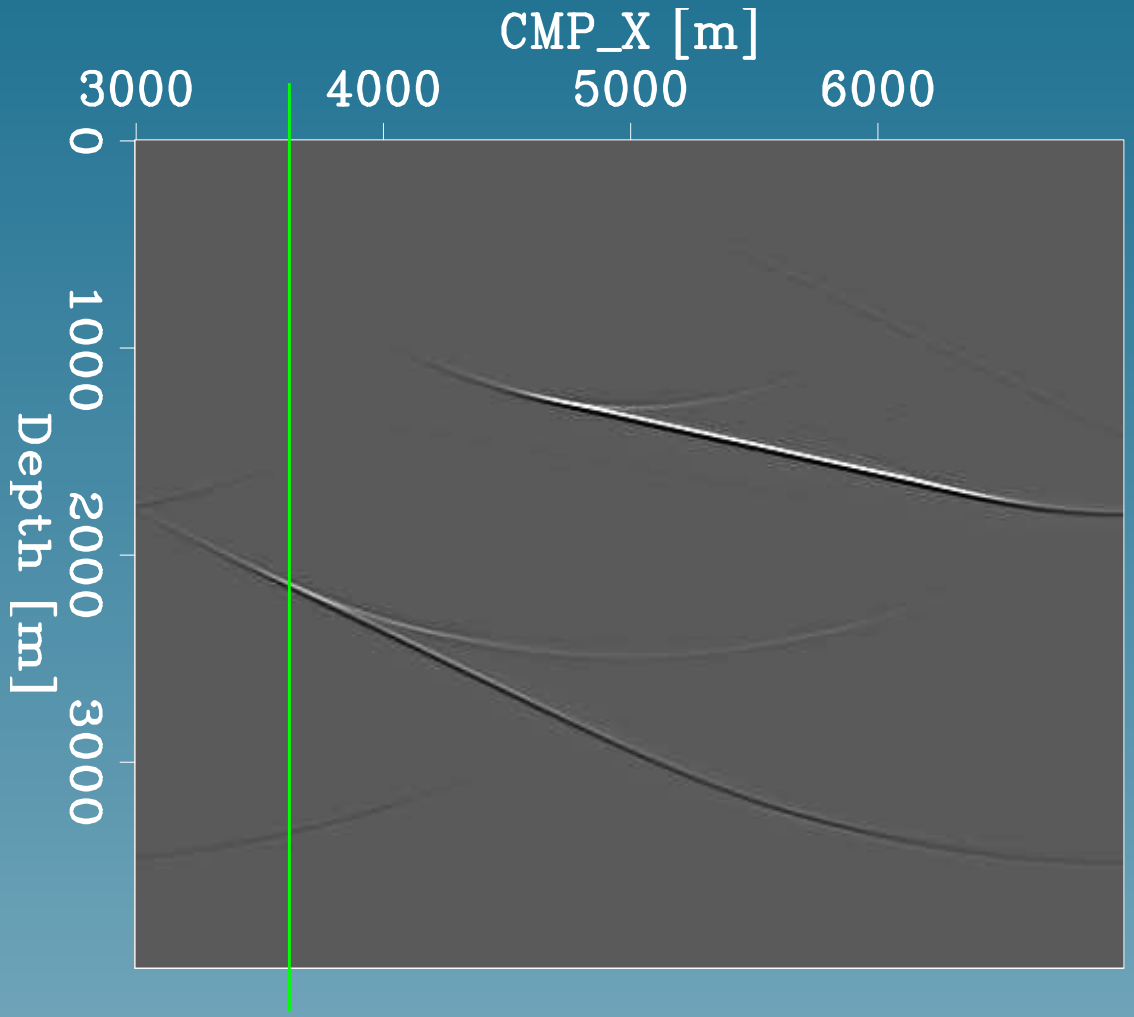


Angle stack

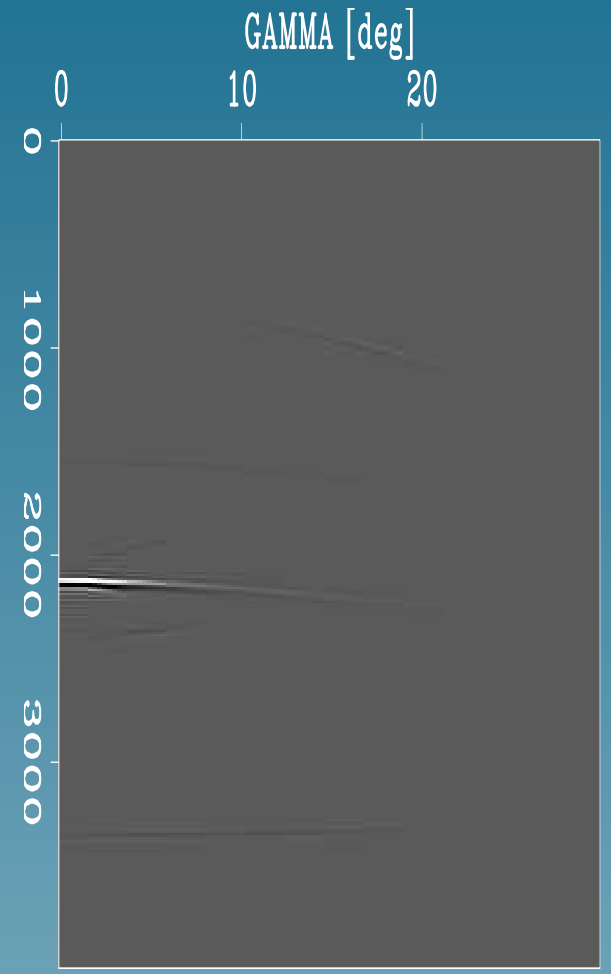


ADCIG (x=6280)

WB Multiple. No Diffraction. Two Vels

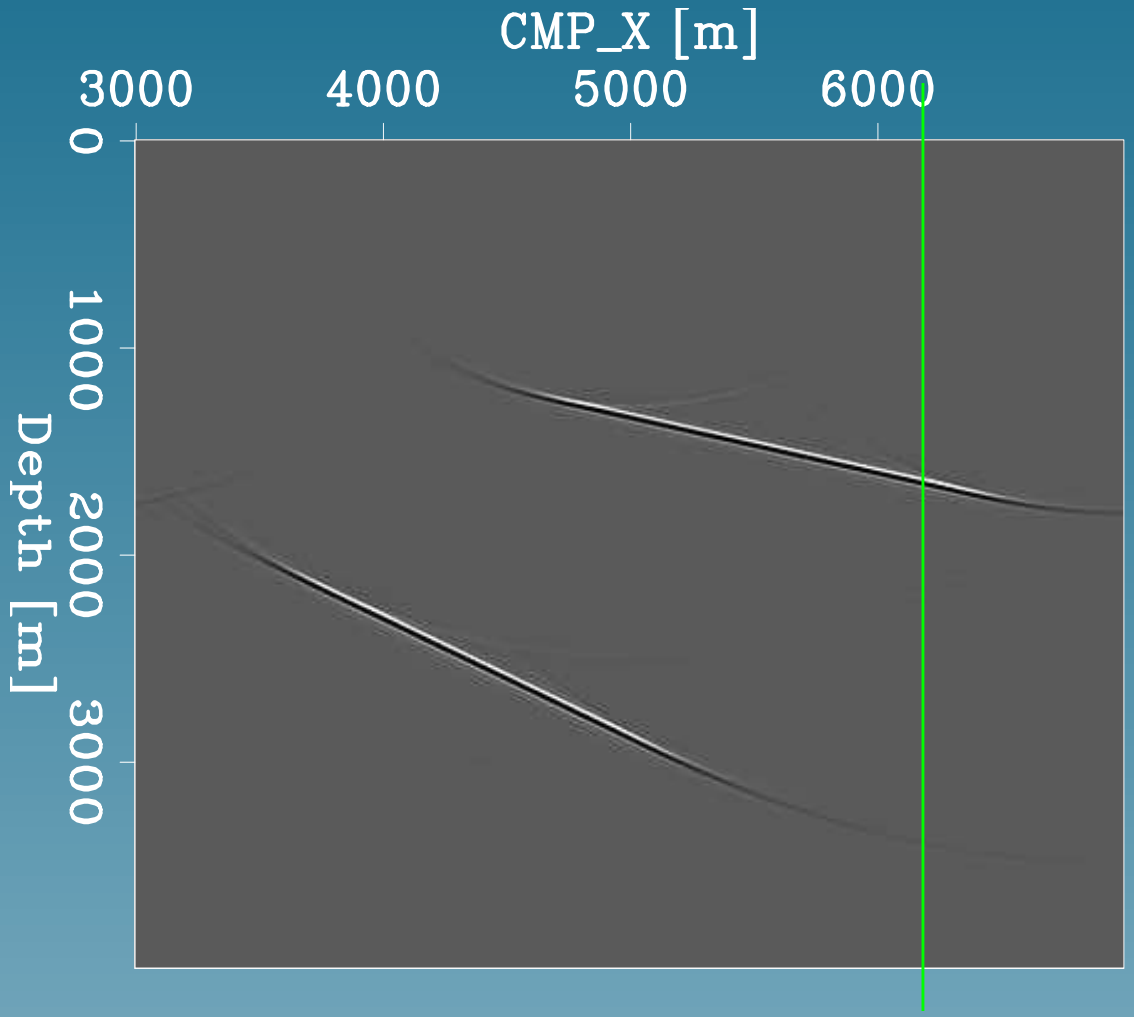


Angle stack

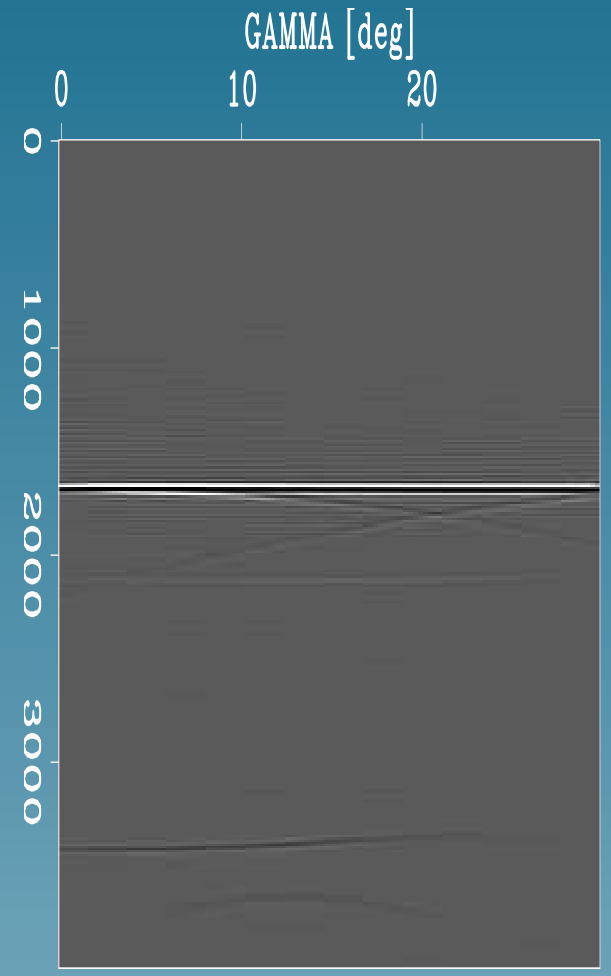


ADCIG (x=6280)

Primary. No Diffraction. One Velocity

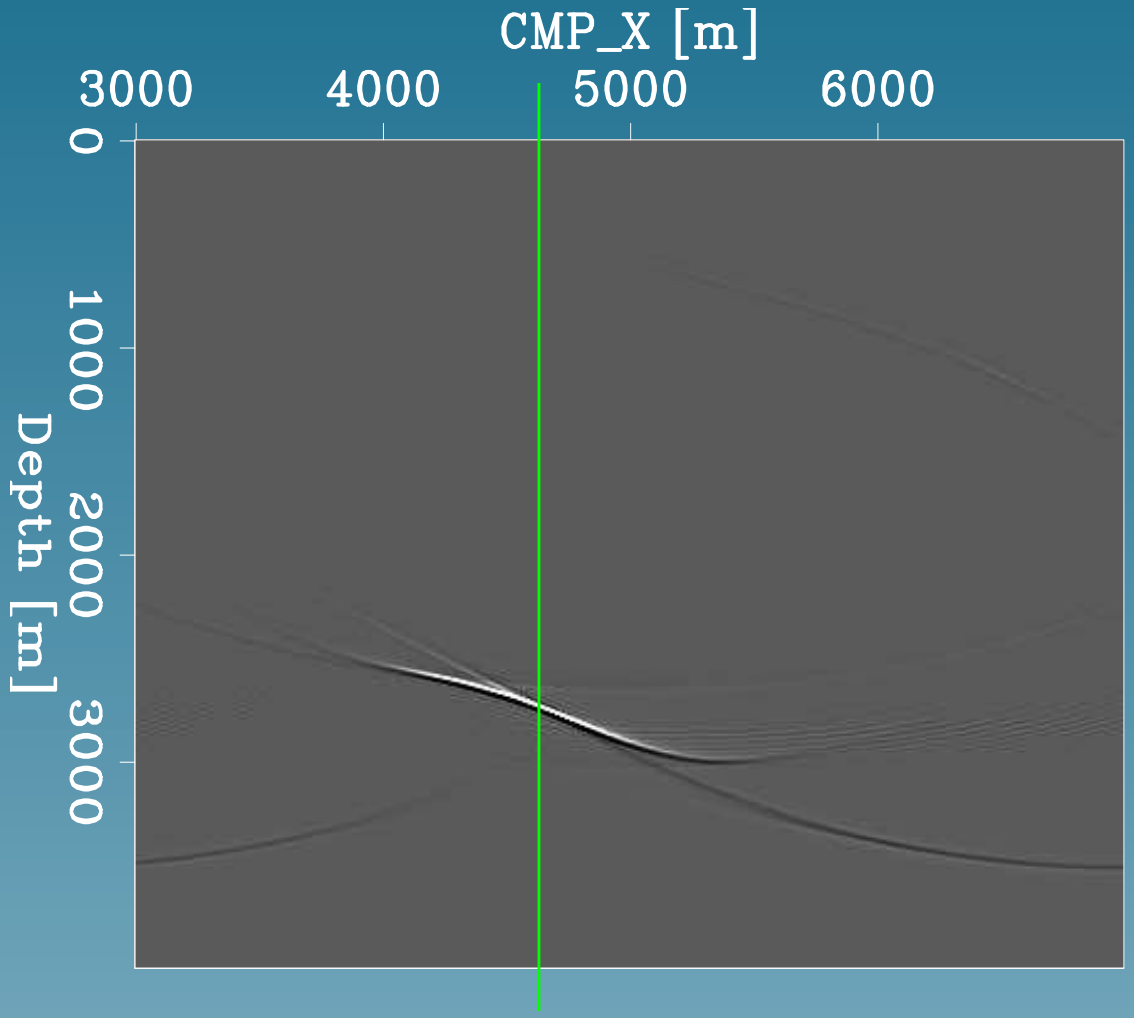


Angle stack

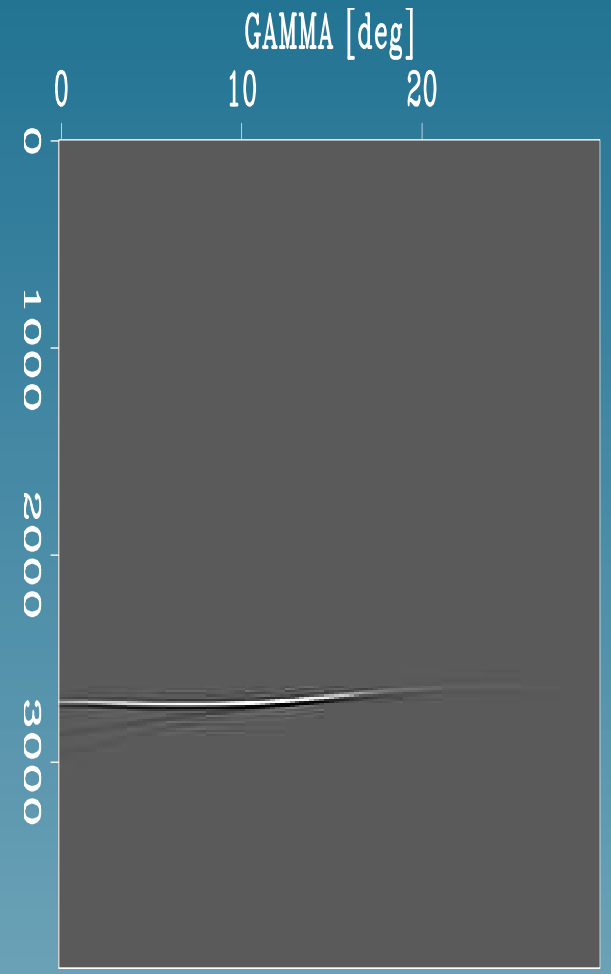


ADCIG (x=6280)

Diffracted Multiple Only. Two Velocities

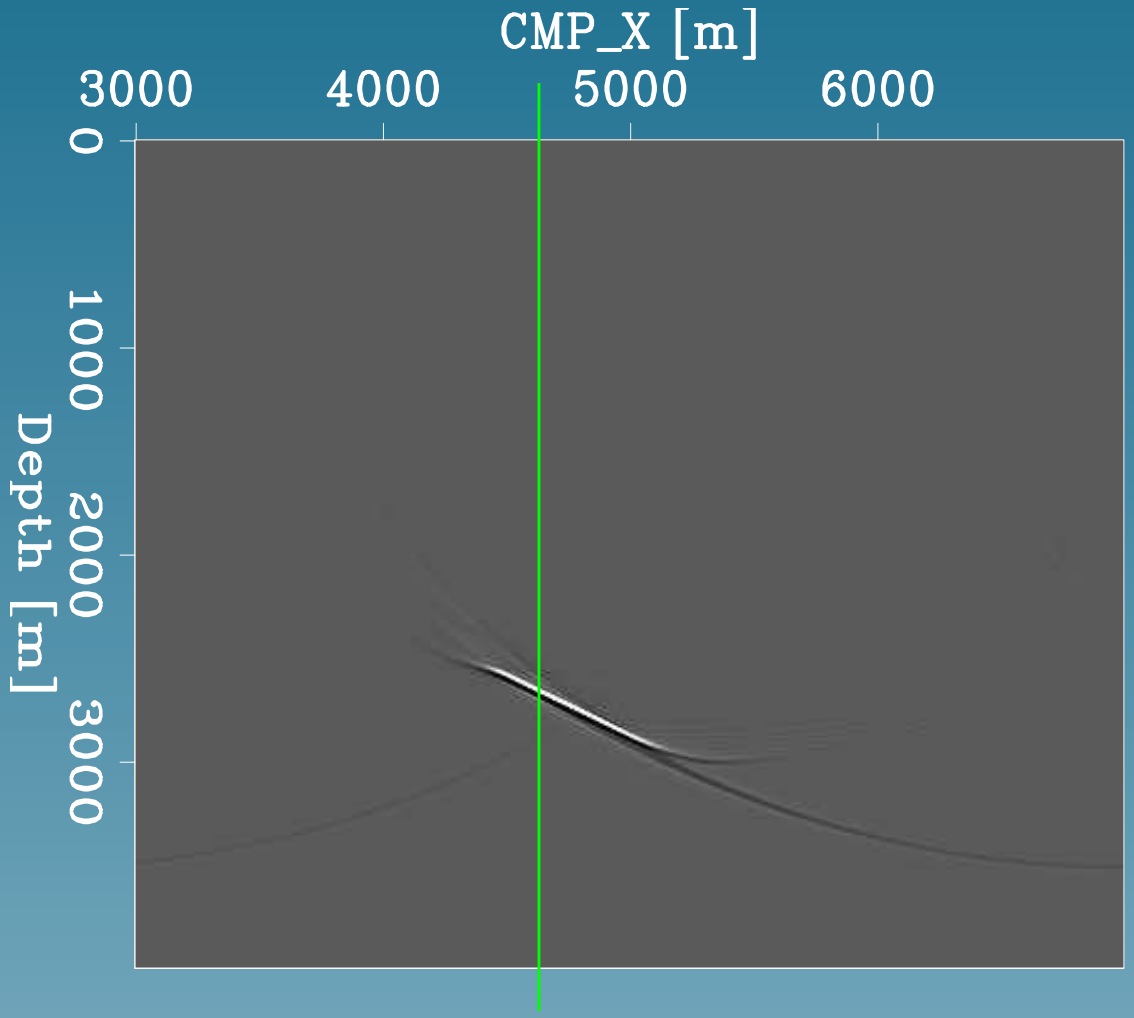


Angle stack

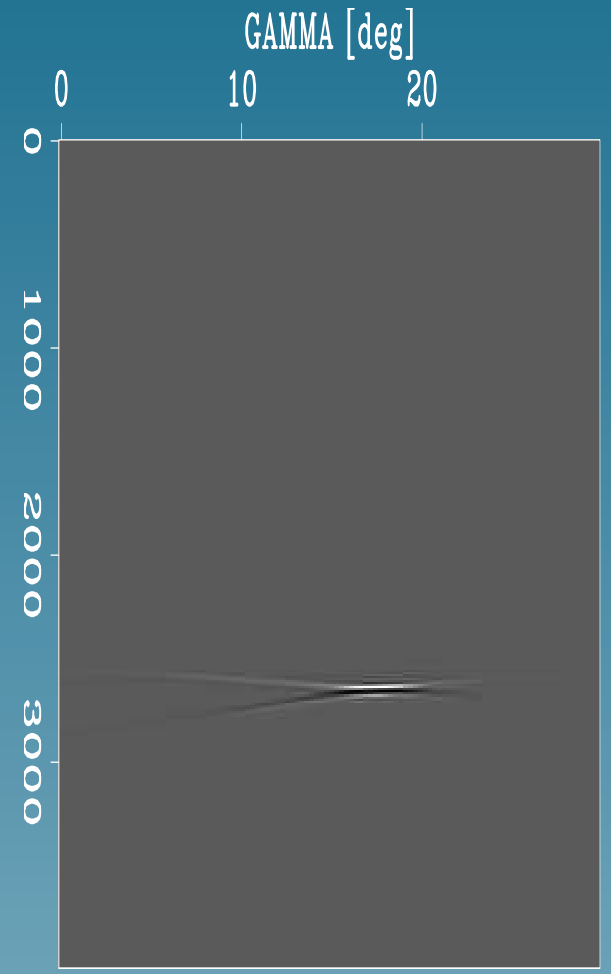


ADCIG (x=4600)

Diffracted Multiple Only. One Velocity



Angle stack



ADCIG (x=4600)

Conclusions

- Water-bottom multiples from a dipping interface behave kinematically as primaries from an interface with twice the dip at twice the depth.

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- Diffracted multiples do not behave like primaries and are not properly migrated even if the correct velocity is used.

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- Water-bottom multiples from a dipping interface behave kinematically as primaries from an interface with twice the dip at twice the depth.
- Diffracted multiples do not behave like primaries and are not properly migrated even if the correct velocity is used.
- Understanding the correct moveout of the multiples in the image space (diffracted multiples in particular) is critical to the design of the proper Radon transform.

Future Work

- Formalize the residual moveout issue for the multiples in the image space.

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- Design the Radon transform that best focuses the multiples in the image space.

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- Design the Radon transform that best focuses the multiples in the image space.
- Apply to synthetic and real 3D data.