Comparing Seismic Imaging Methods (Pre & Post Stack)

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1 Introduction

2 Channel model

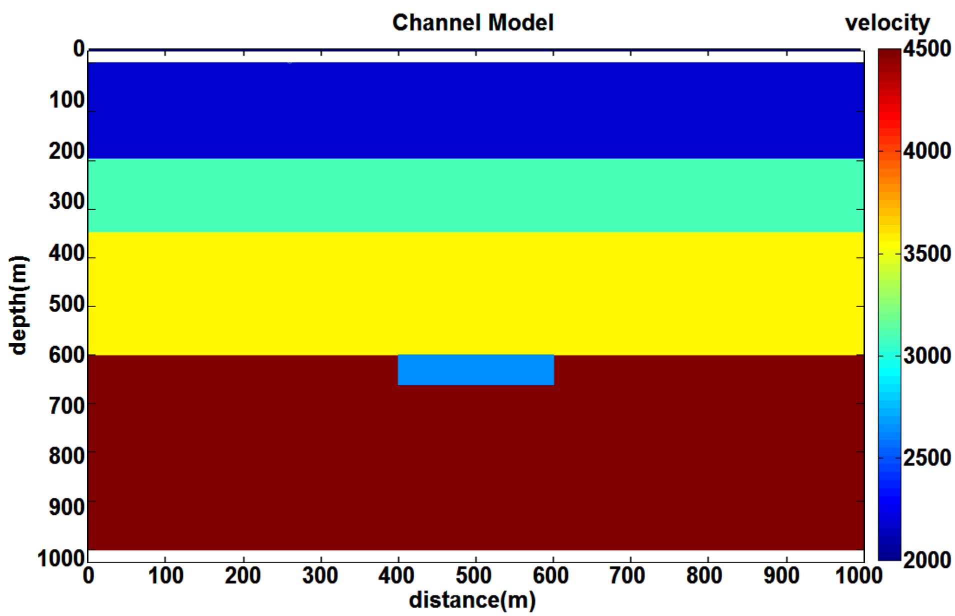
3 Marmousi model

4 Conclusions

1 Introduction

- Migration of seismic data can move dipping events to their correct positions, collapse diffractions and increase spatial resolution.
- In pre-stack migration, seismic data is adjusted before stacking sequence occurs.
- Post-stack migration operates on the stacked section which is assumed to be zero-offset section.

2 Channel Model



- Horizontal layers without dips or lateral velocity variations
- 40 sources: $\Delta s = 4m$

  250 receivers: $\Delta r = 24m$
- Stability condition:

$$dtstep \le \sqrt{\frac{3}{8}}\frac{dx}{V_{\max}}$$

$$dtstep = 0.2ms, dx = 2m$$

$$V_{\max} = 4500\, m/s$$

- Kirchhoff time migration

Pre-stack Migration

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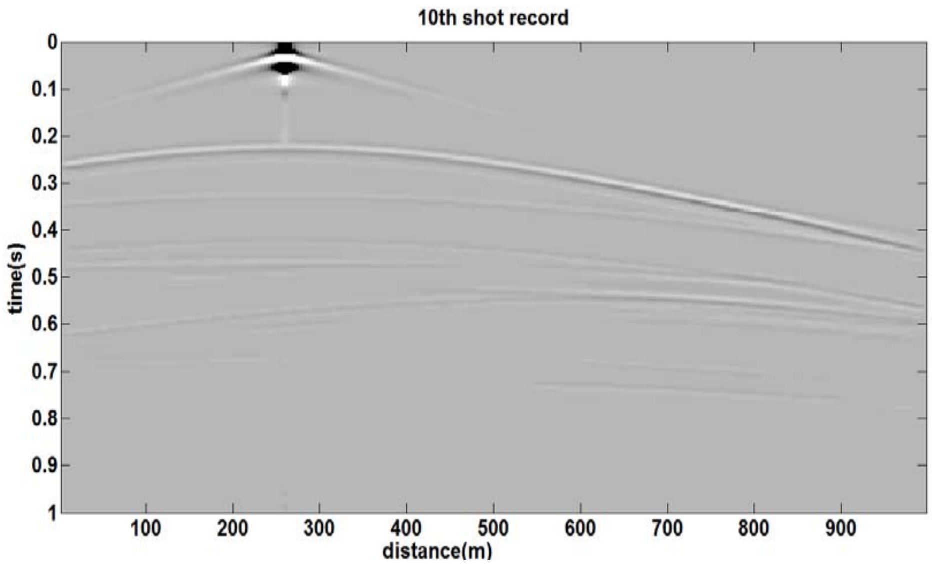
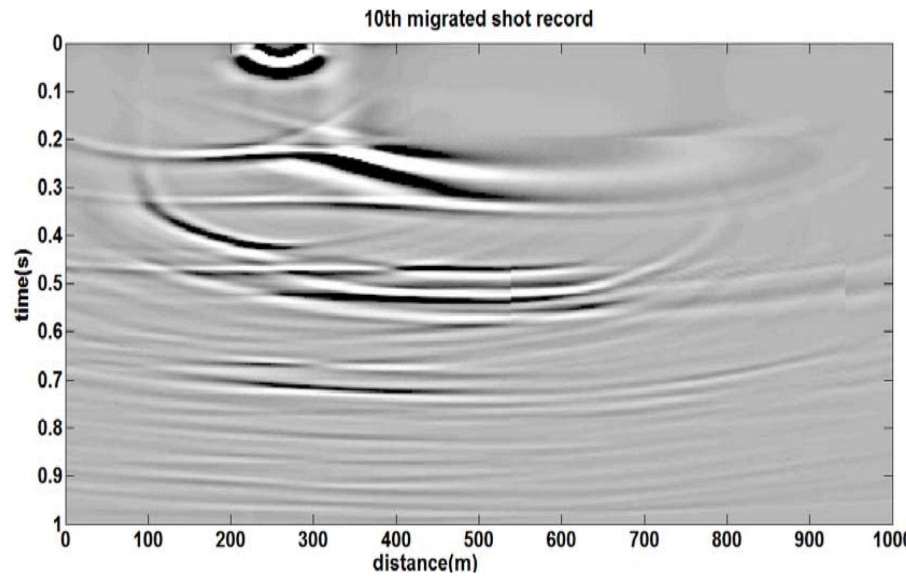
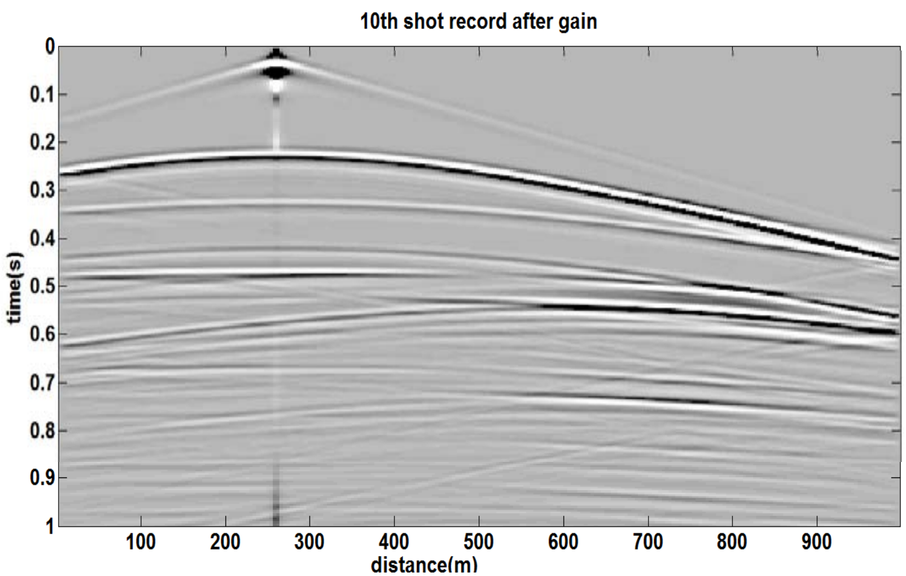
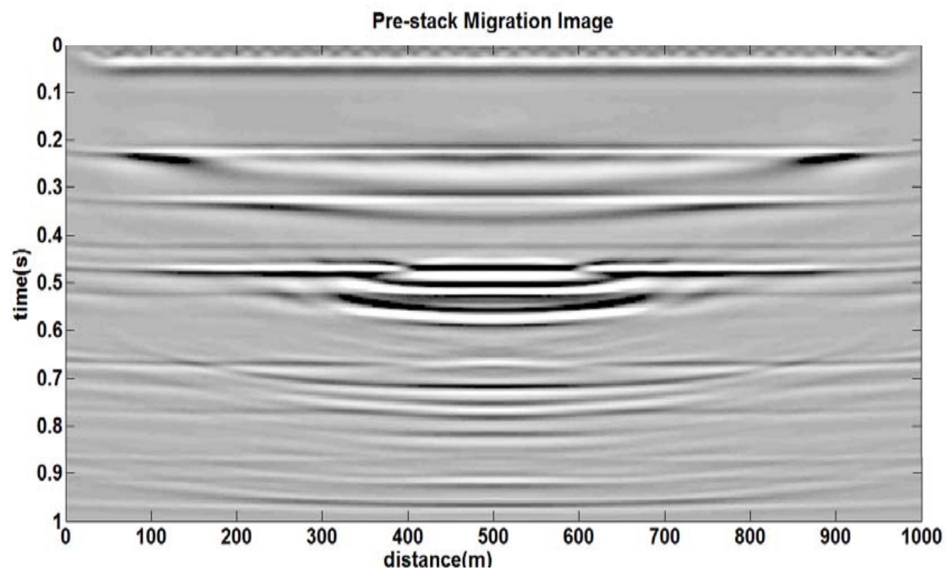
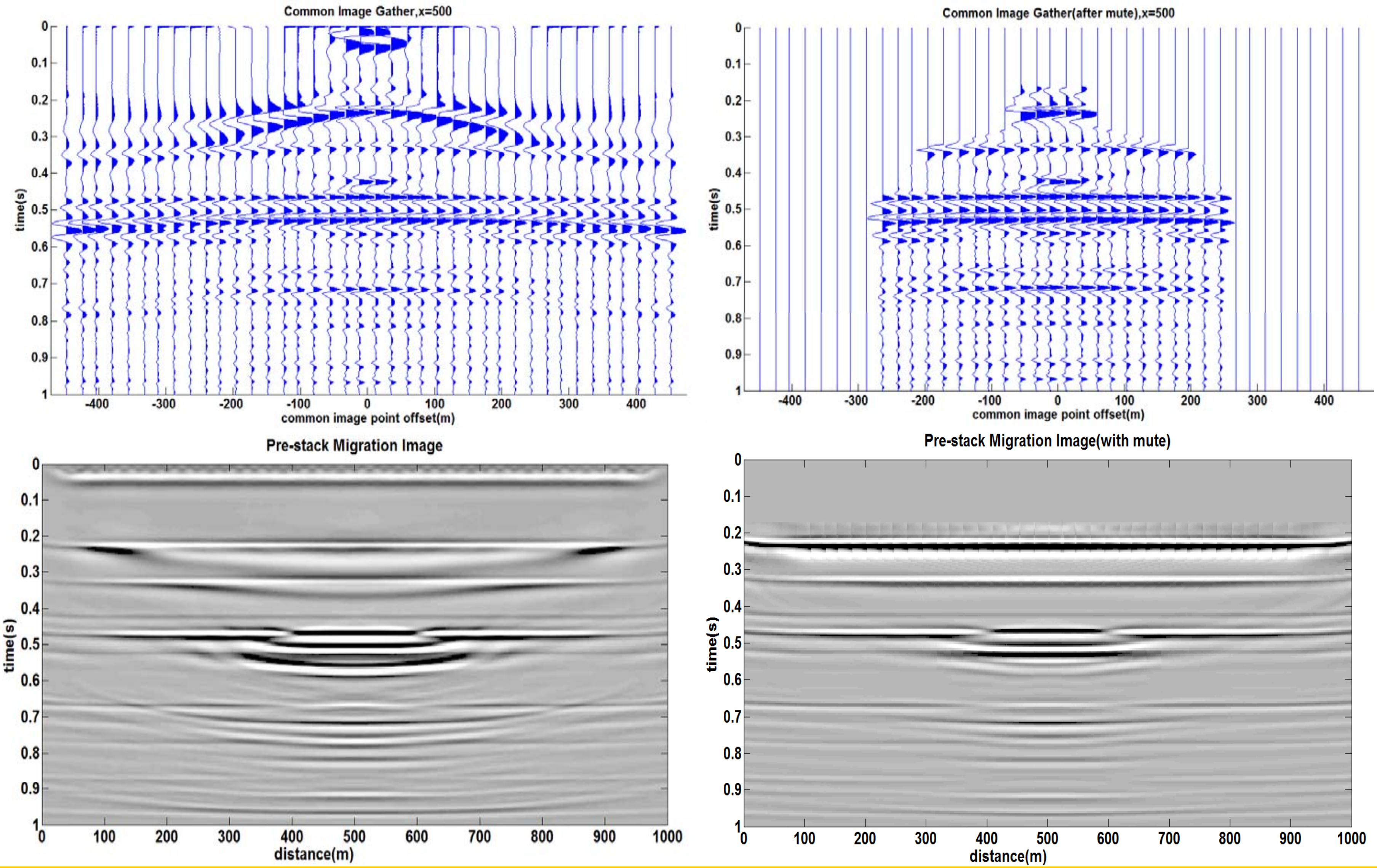




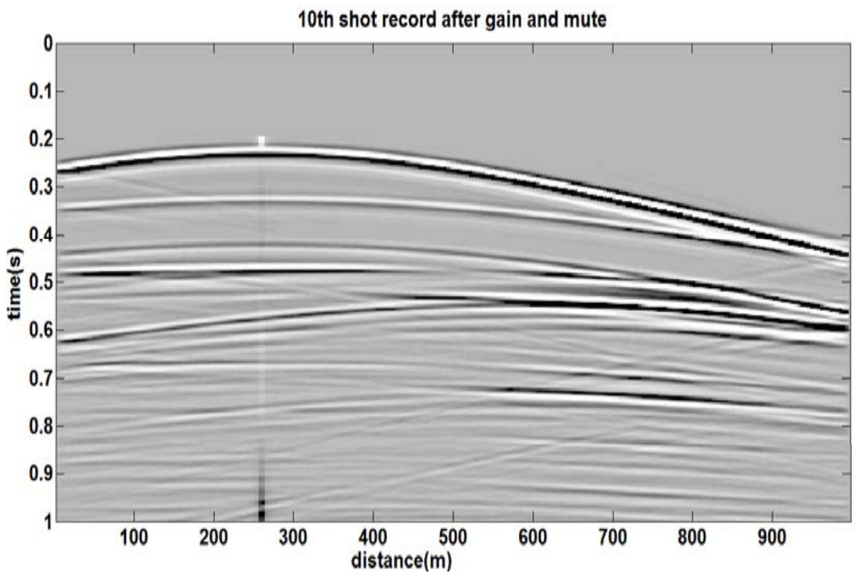


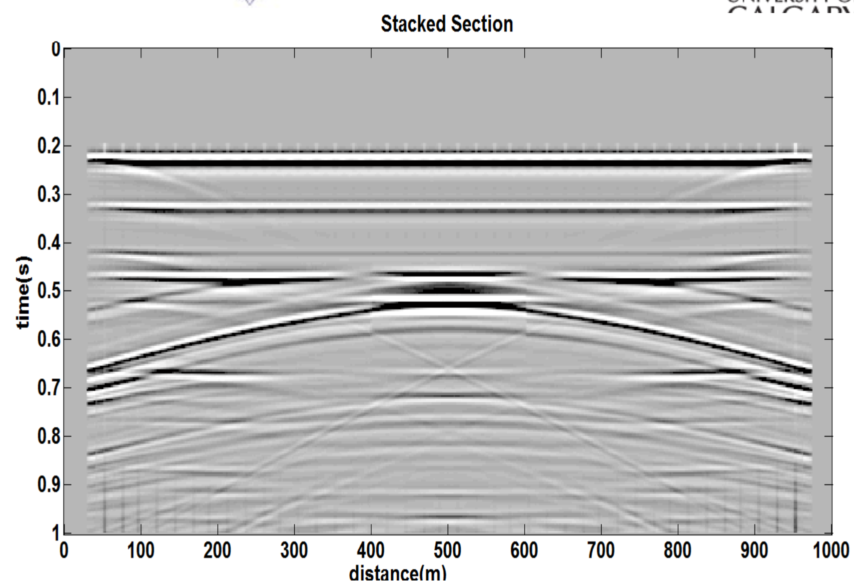


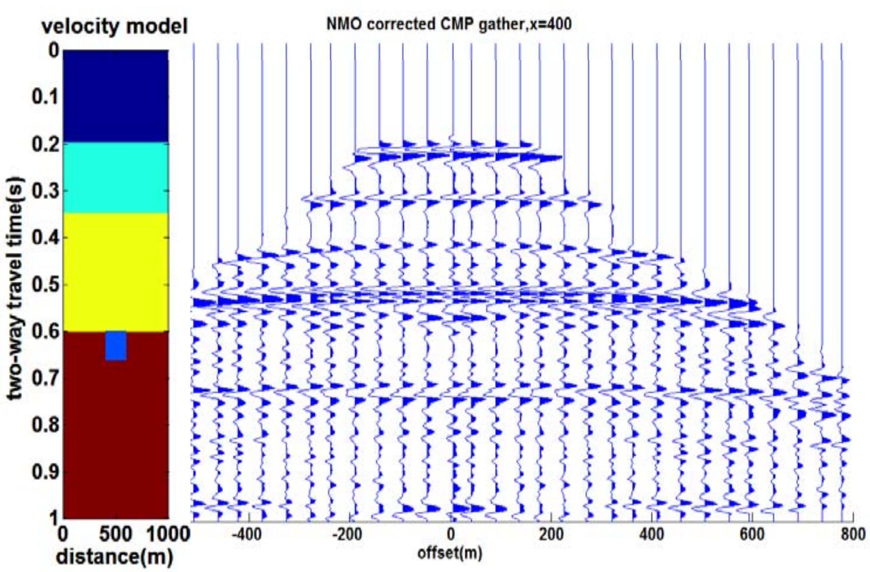
Pre-stack Migration

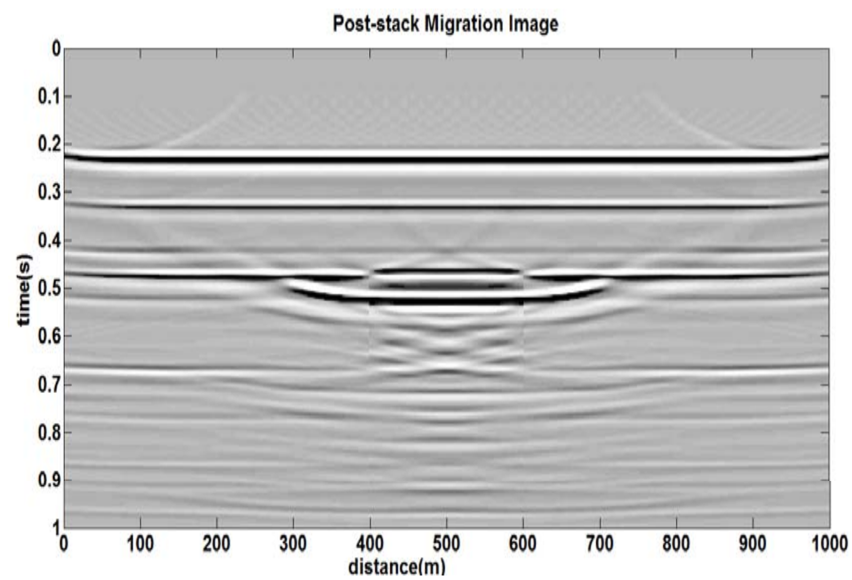


Post-stack Migration

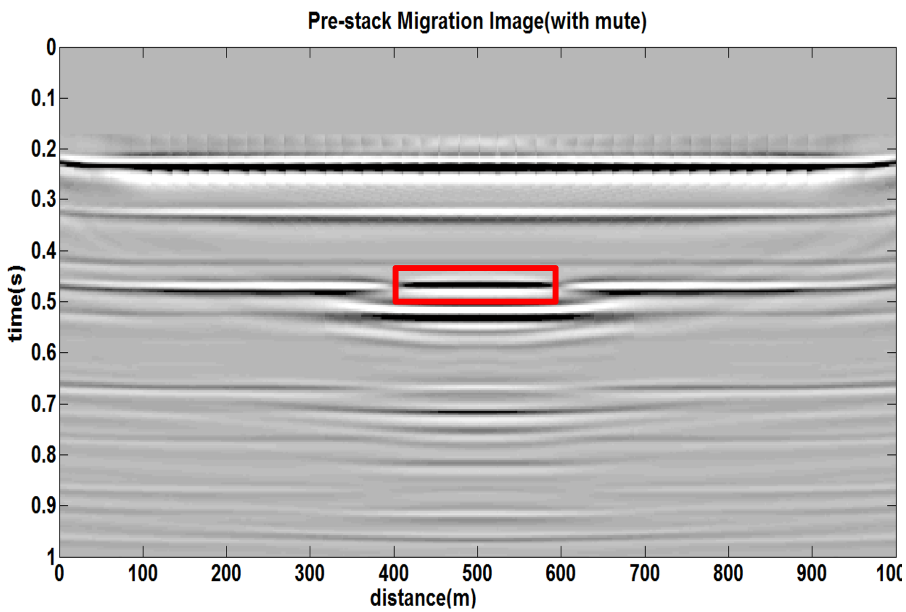


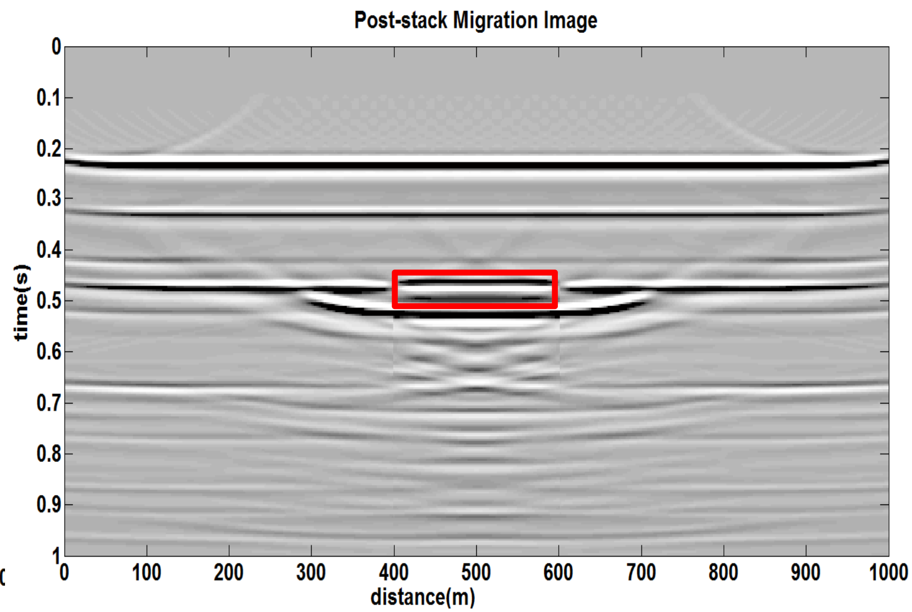






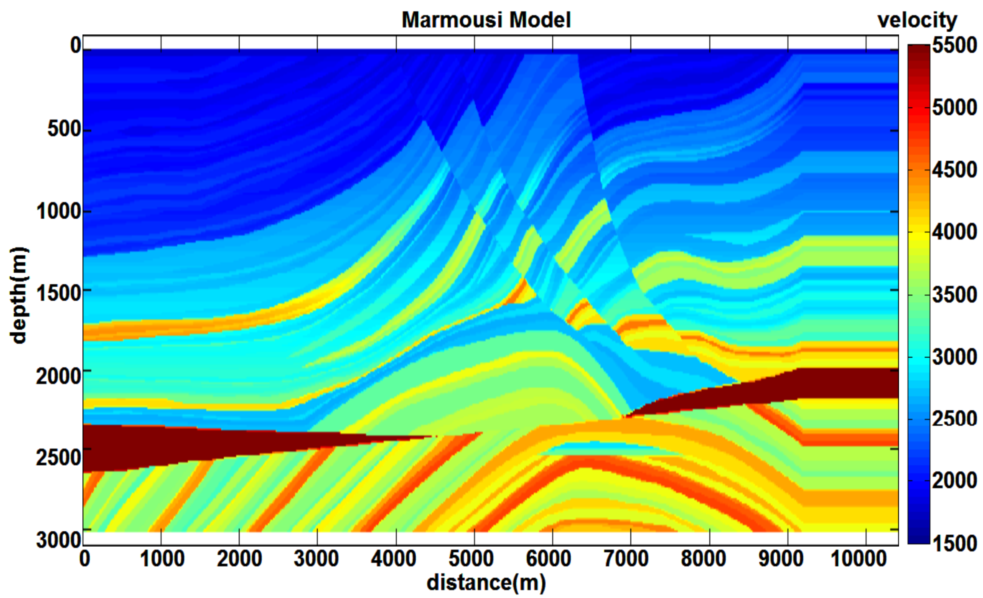
Comparison





- Pre and post migration both image three interfaces well.
- Pre and post migration both image the channel similarly.

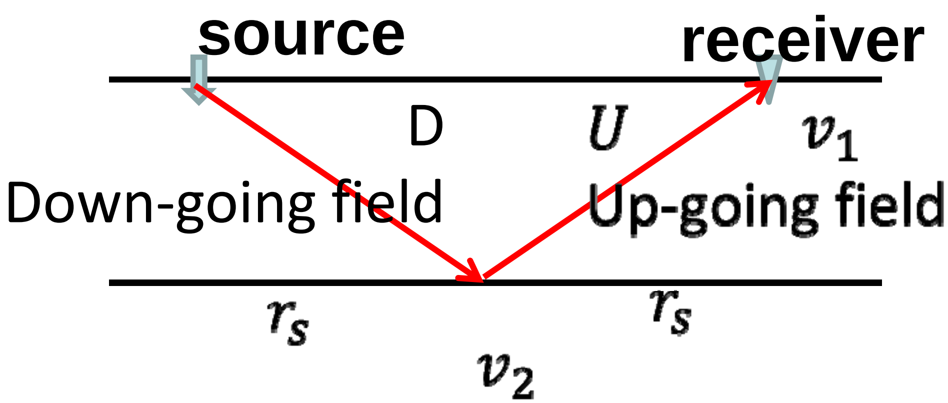
3 Marmousi Model



- Faults, unconformity, anticline
- 41 sources: $\Delta s = 100m$

  1251 receivers: $\Delta r = 8.33m$
- PSPI depth migration

Pre-stack Migration Imaging Condition



$U(\vec{x},\omega) = R_T \frac{W_T(\omega)}{4\pi r_s} e^{ikr_s}$

R_T True reflection coefficient

$W_T(\omega)$ True wavelet

$k = \frac{\omega}{v_1}$ Wavenumber

$D(\vec{x},\omega) = \frac{W(\omega)}{4\pi r_s} e^{ikr_s}$

$W(\omega)$ Wavelet estimate

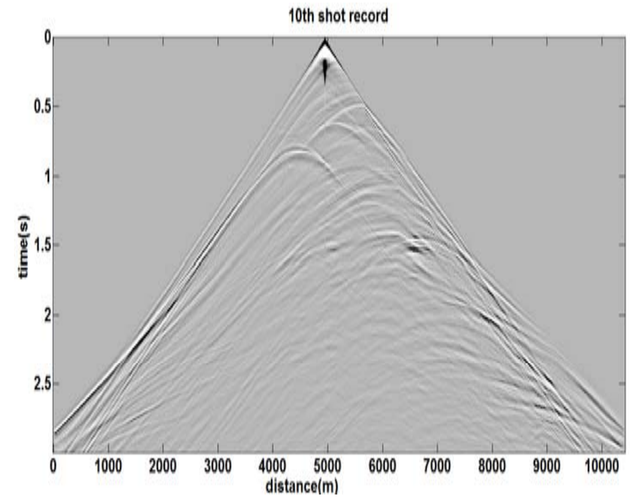
$Cross-Correlation: R_c = U(\vec{x},\omega) D^*(\vec{x},\omega) = \frac{R_T W_T(\omega) W^*(\omega)}{r_s^2 (4\pi)^2}$

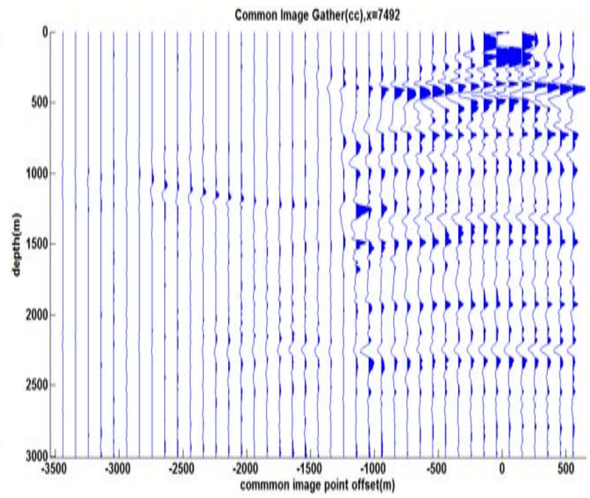
$Cross-Correlation\ (Gained): R_{cg} = R_T \frac{W_T(\omega) W^*(\omega)}{(4\pi)^2}$

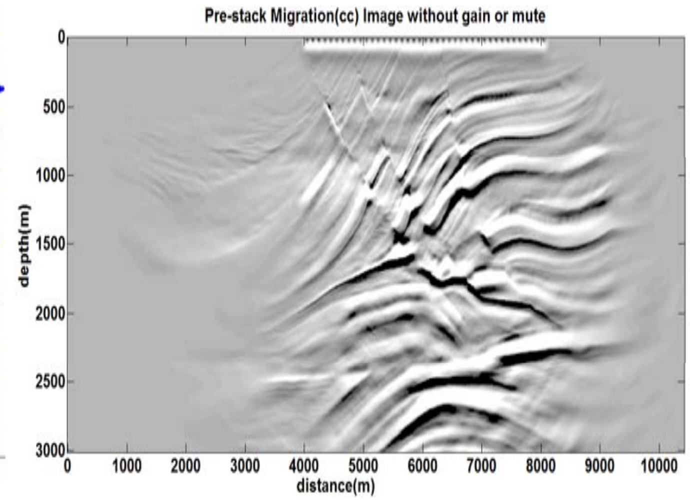
$Deconvolution\ (Stablized): R_{ds} = \frac{U(\vec{x},\omega) D^*(\vec{x},\omega)}{\|D(\vec{x},\omega)\|^2 + \mu D_{max}}$, μ stability factor

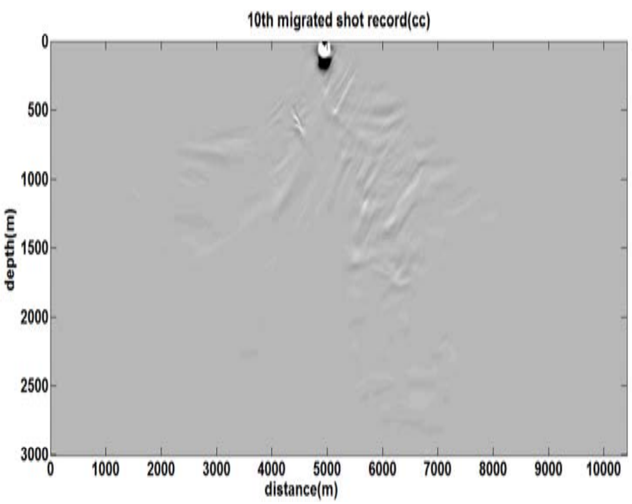
$Deconvolution: R_d = \frac{U(\vec{x},\omega)}{D(\vec{x},\omega)} = R_T \frac{W_T(\omega)}{W(\omega)}$

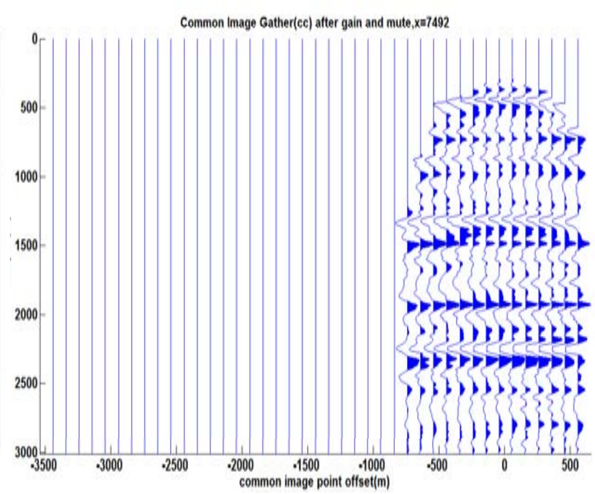
Pre-stack Migration
Cross-Correlation Imaging Condition

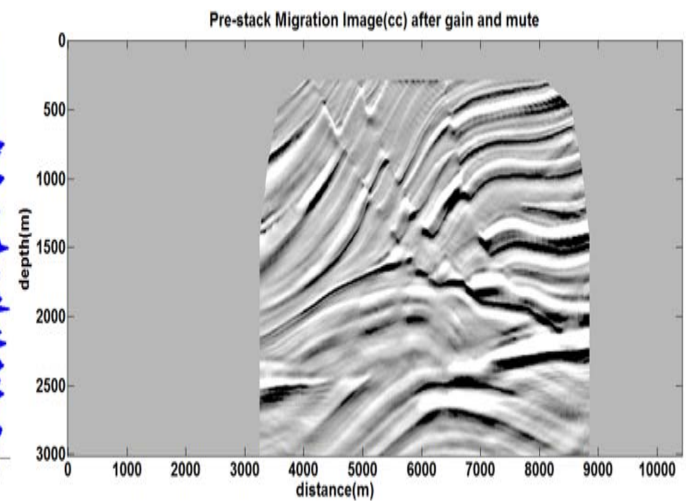






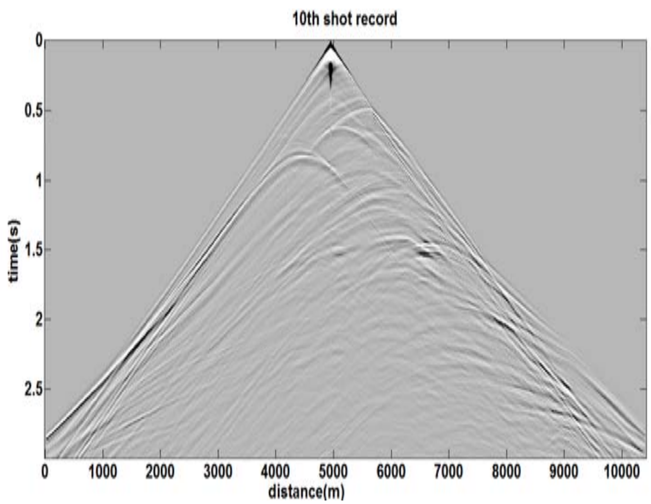


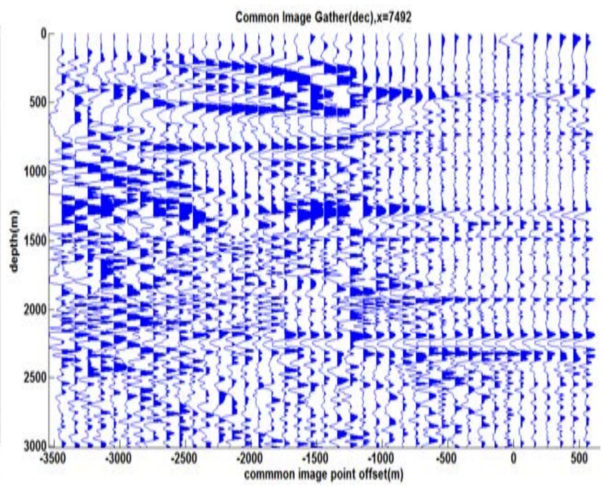


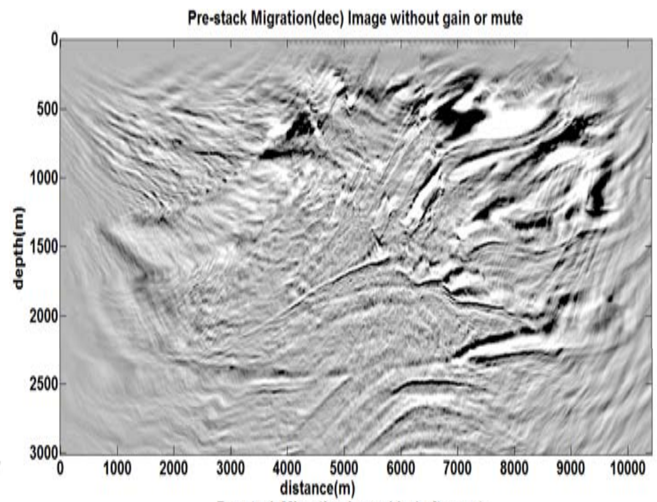


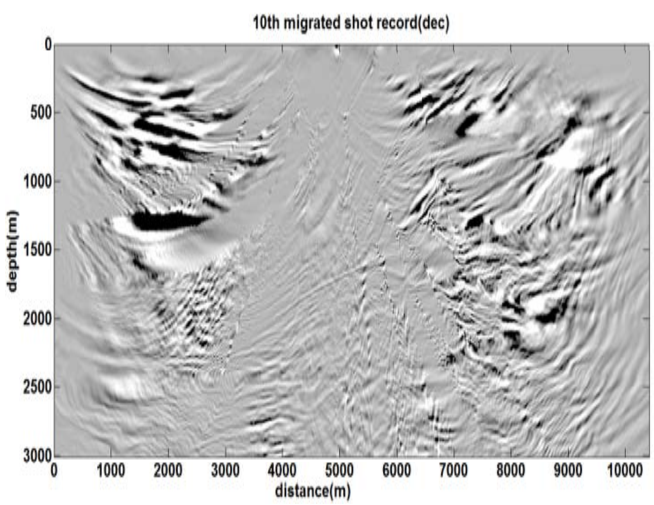
Pre-stack Migration

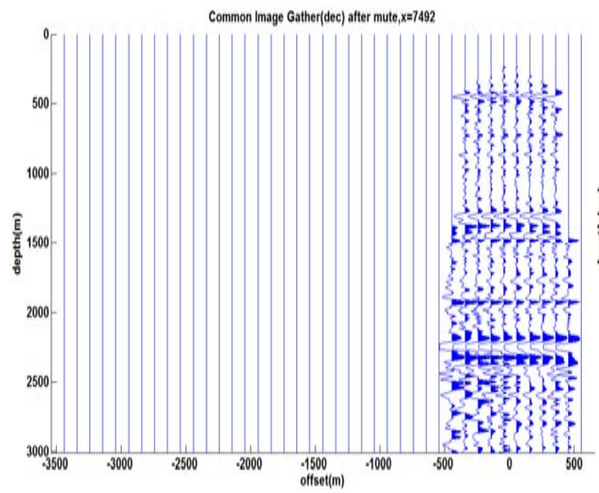
Stabilized Deconvolution Imaging Condition, μ=0.0001

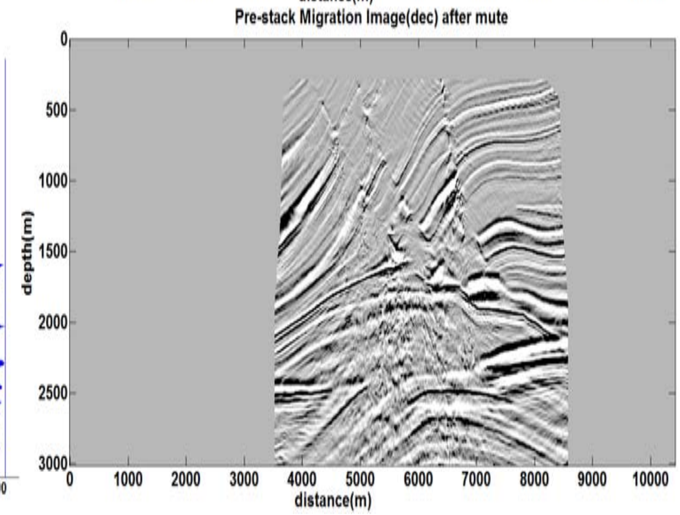








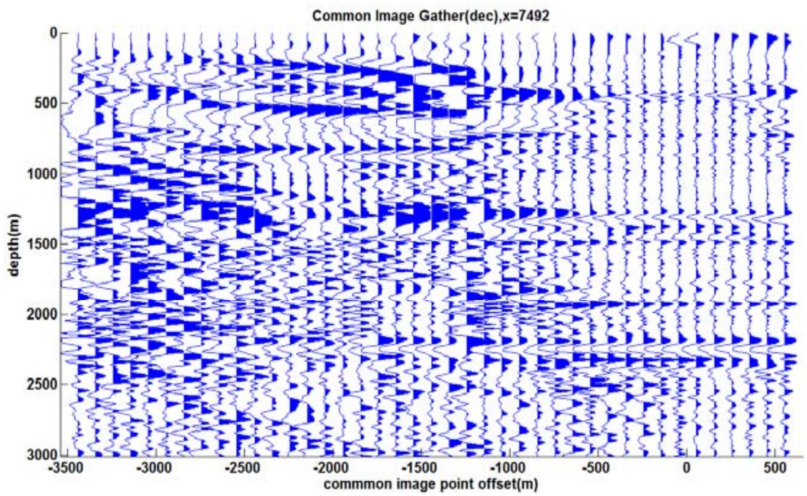


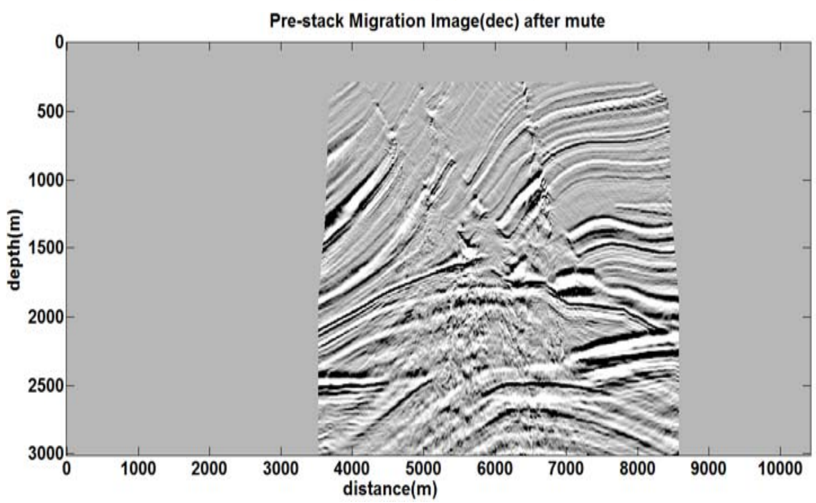


Pre-stack Migration

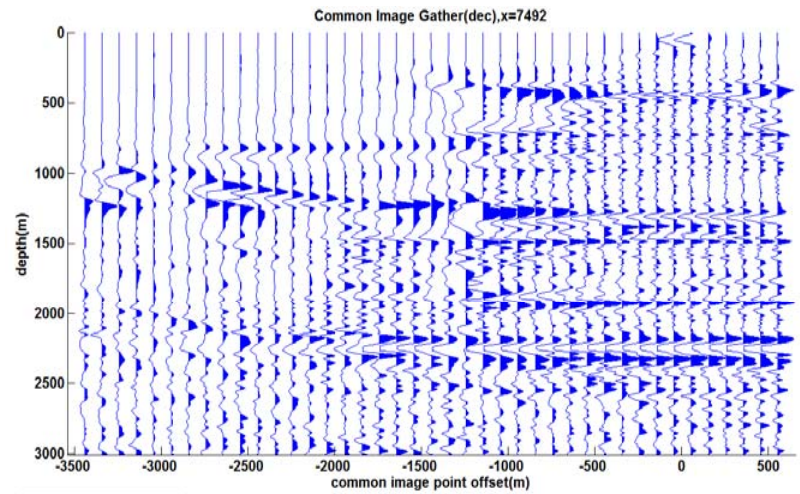
Stabilized Deconvolution Imaging Condition

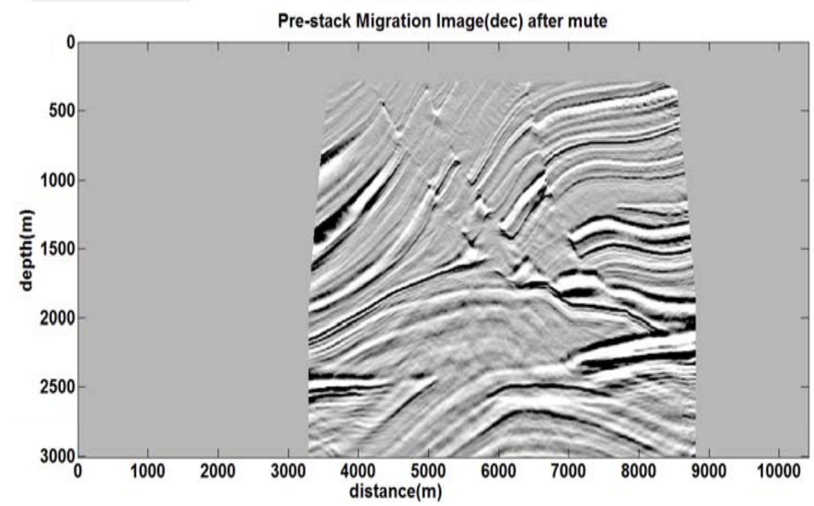
μ=0.0001



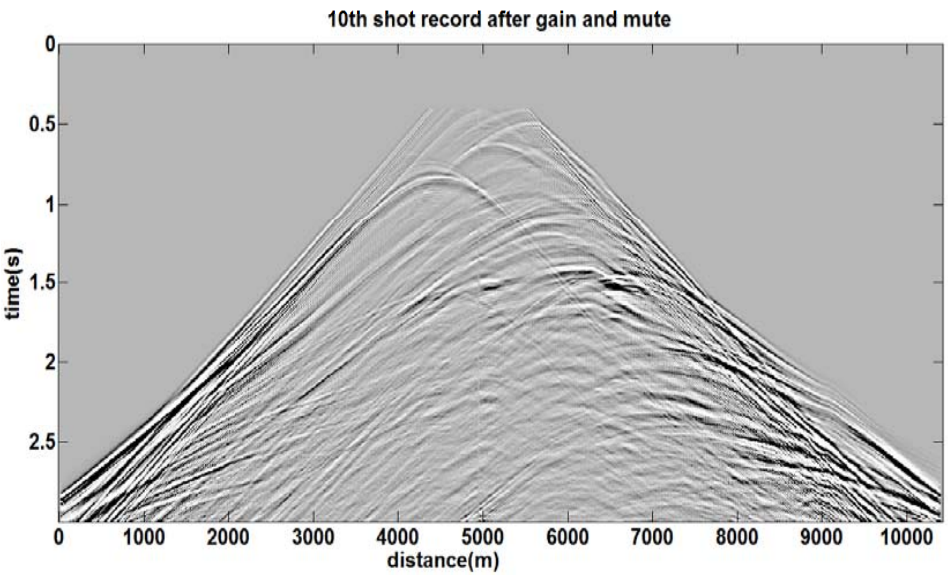


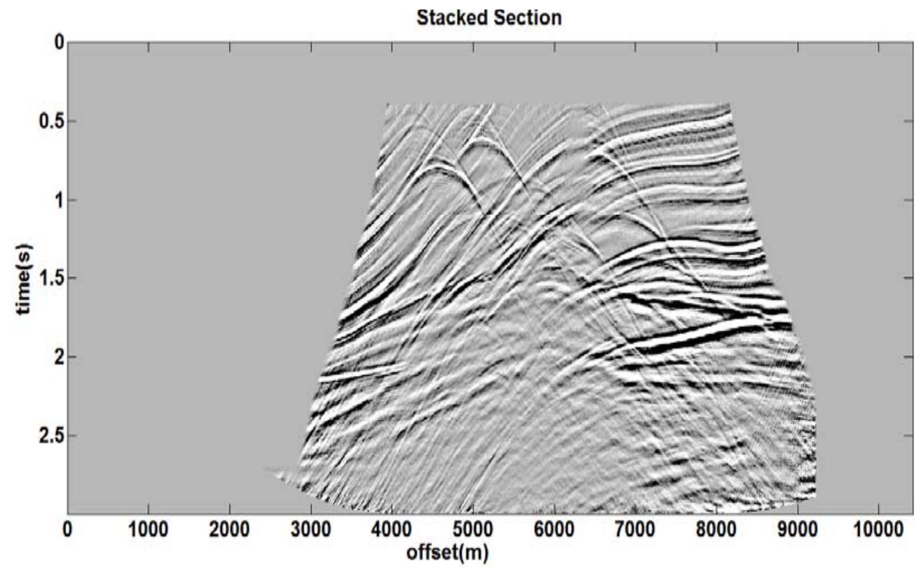
μ=0.01

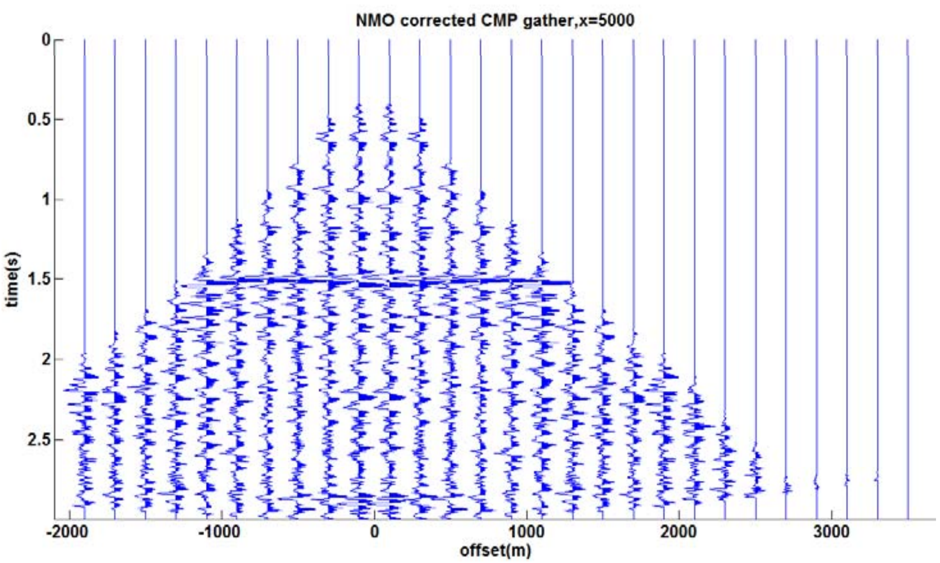


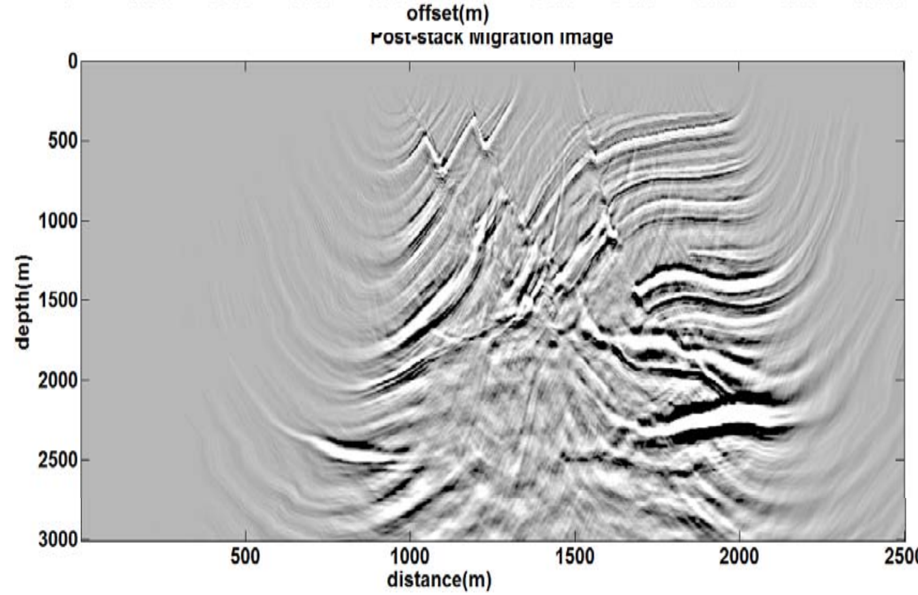


Post-stack Migration

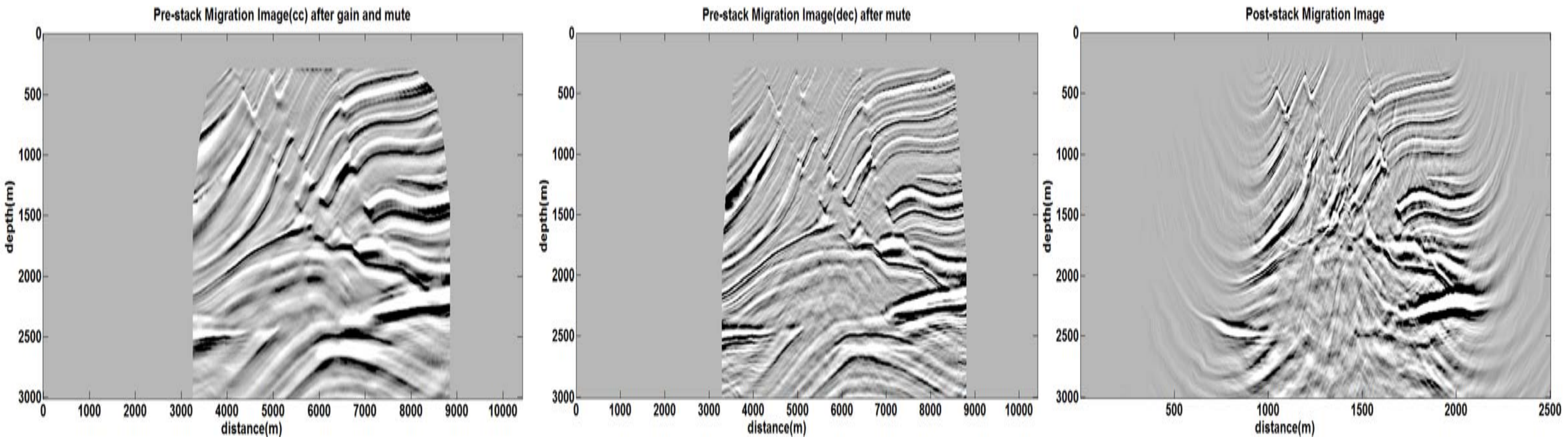








Comparison



- Migration image has a higher resolution under deconvolution imaging condition than cross-correlation imaging condition.
- Pre-stack migration images better than post-stack migration.

Comparison of Calculation Time

Calculation Time	Channel Model (Kirchhoff time migration)	Marmousi Model (PSPI depth migration)
Post-stack Migration	33 (s)	318 (s)
Pre-stack Migration	23.5*40=940 (s)	440*41=18040 (s)

- In both models, post-stack migration spends much less time than the corresponding pre-stack migration.

4 Conclusions

- For a simple model without dips or lateral velocity variations, post-stack migration and pre-stack migration have similar imaging results.
- For a complex model with large dips and strong lateral velocity variations, pre-stack migration images better than post-stack migration method.
- Muting migrated data correctly can improve imaging quality.
- Post-stack migration is much faster than the corresponding pre-stack migration.

Acknowledgement

- Professor Margrave
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- CREWES sponsors

Questions & Comments