

# Full Waveform Inversion – A Synthetic Test Using the PSPI Migration

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# Outline

- Introduction
- Synthetic survey
- Cost
- Initial Velocity Model
- Marmousi
- Conclusions
- Future work
- Acknowledgments

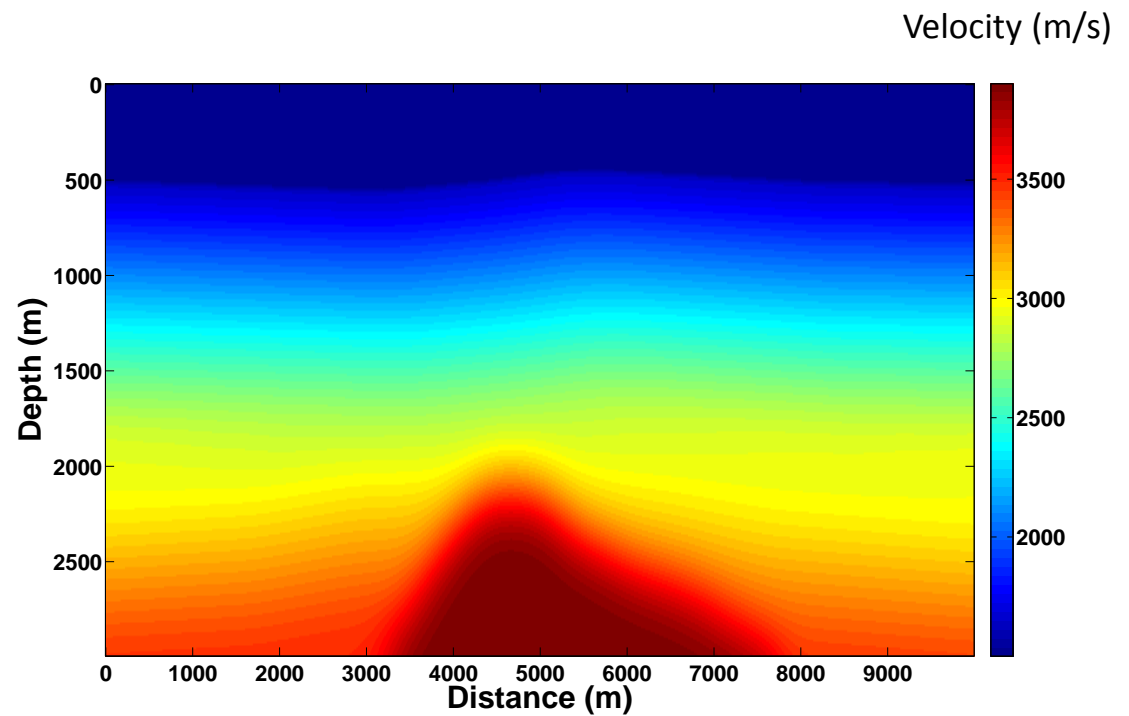
# Introduction

- Iterative **Minimize**  $\rightarrow \Phi(m) \equiv \|\Delta d\|^2$

# Introduction

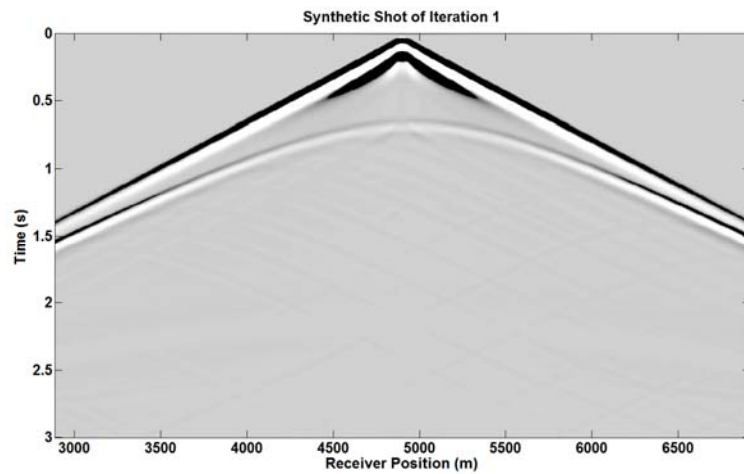
$m_0$

- Iterative



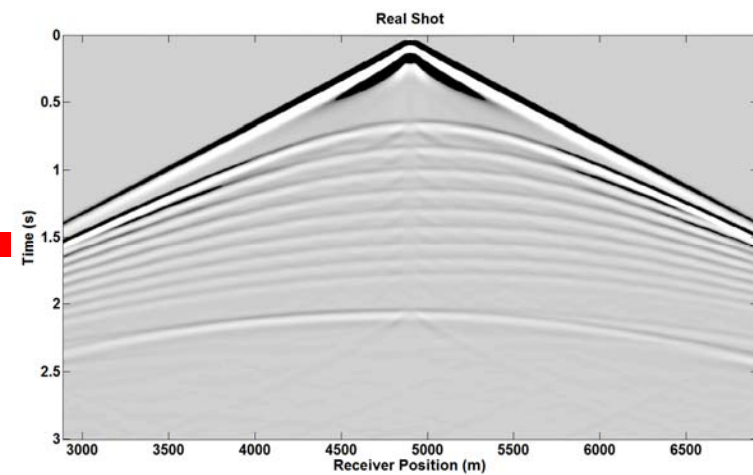
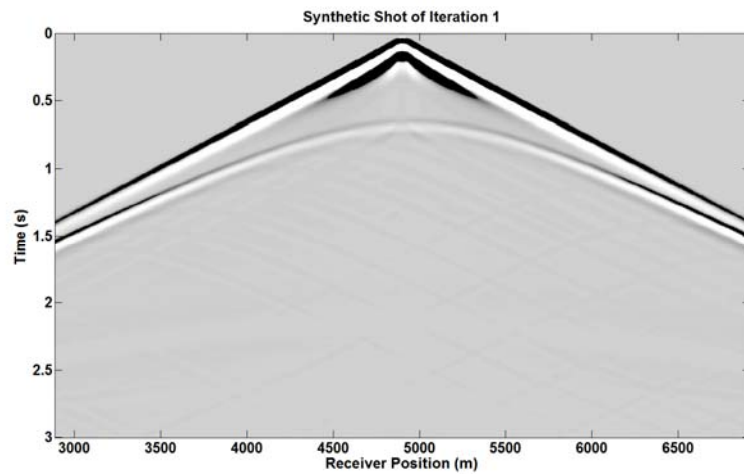
# Introduction

$d_{syn}$



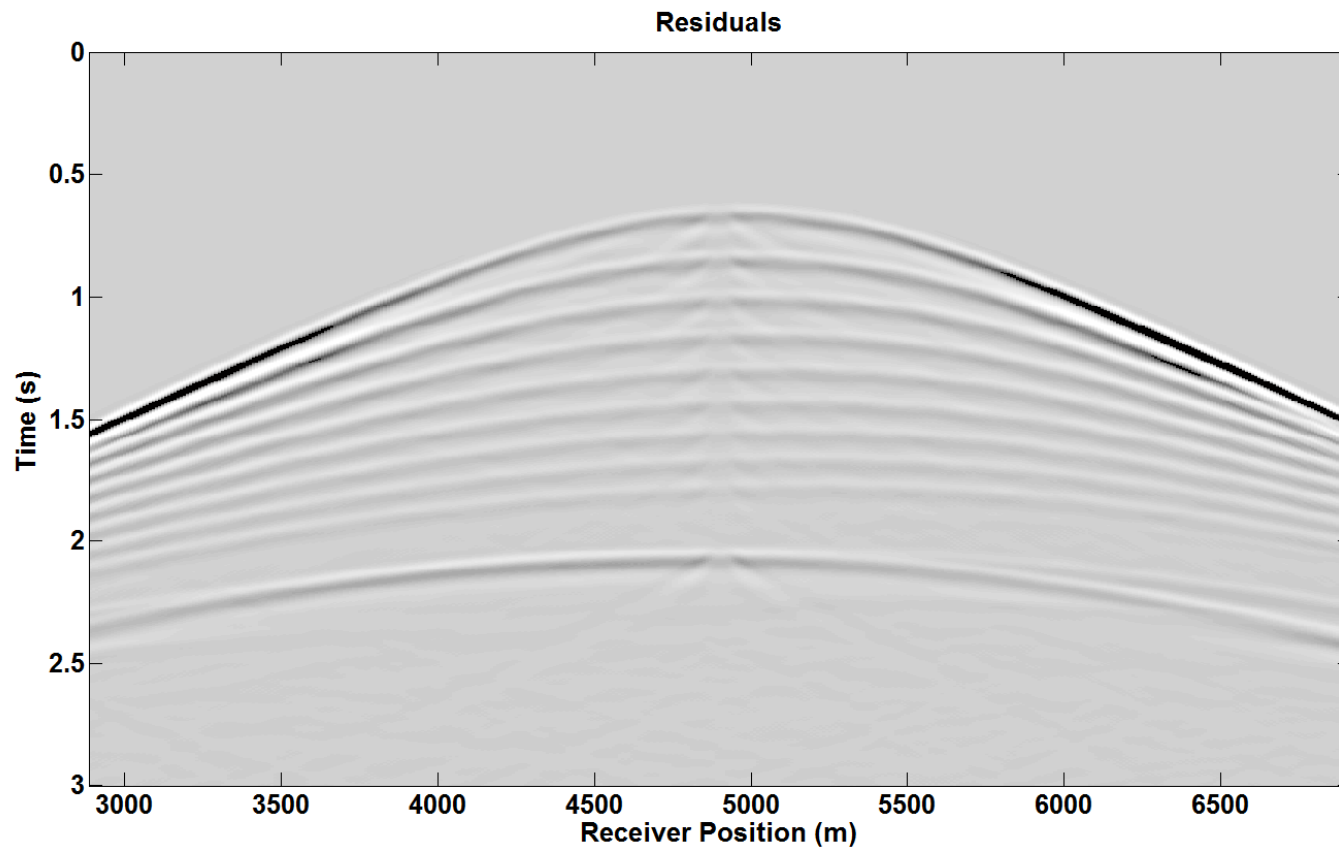
# Introduction

$$d_{syn} - d_{obs}$$

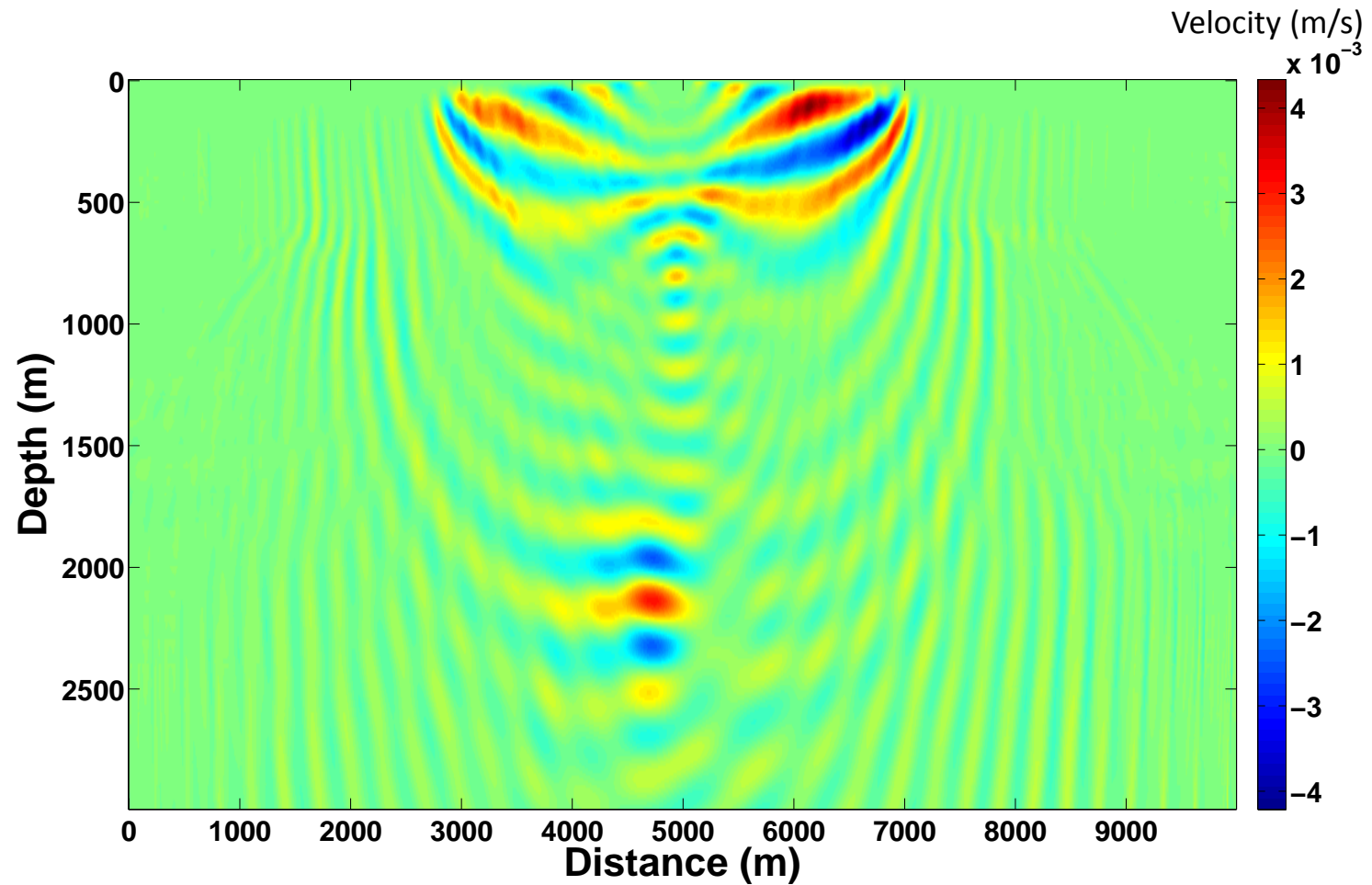


# Introduction

$$\Delta d = d_{syn} - d_{obs}$$



# Introduction

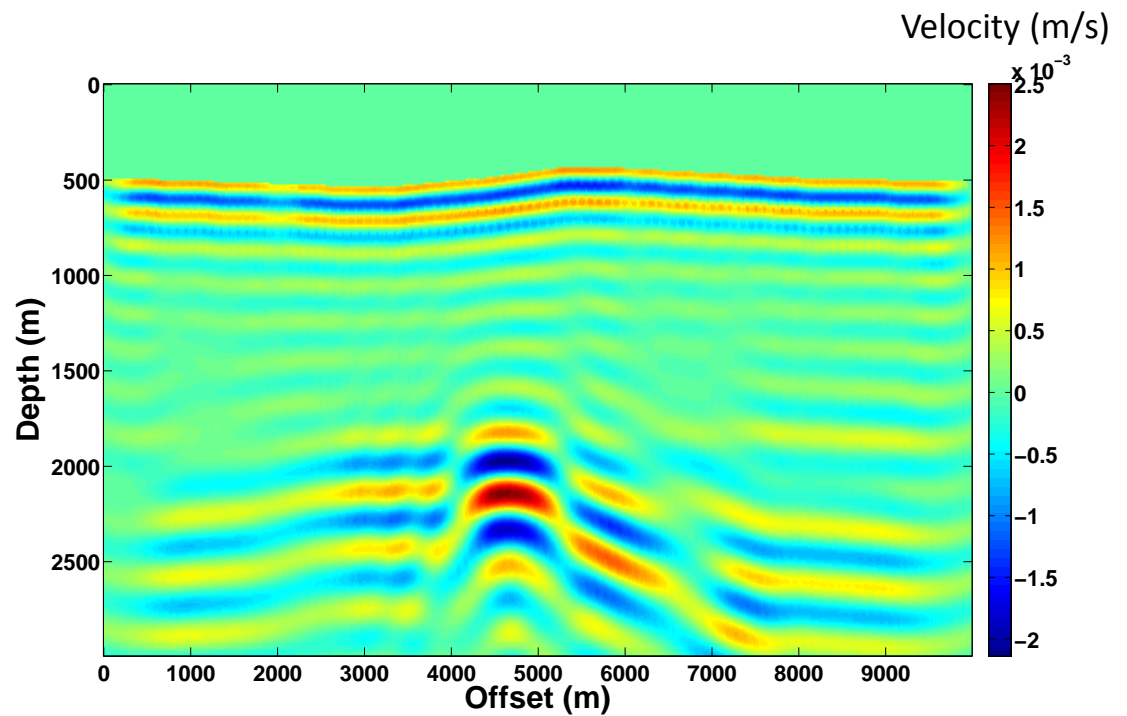




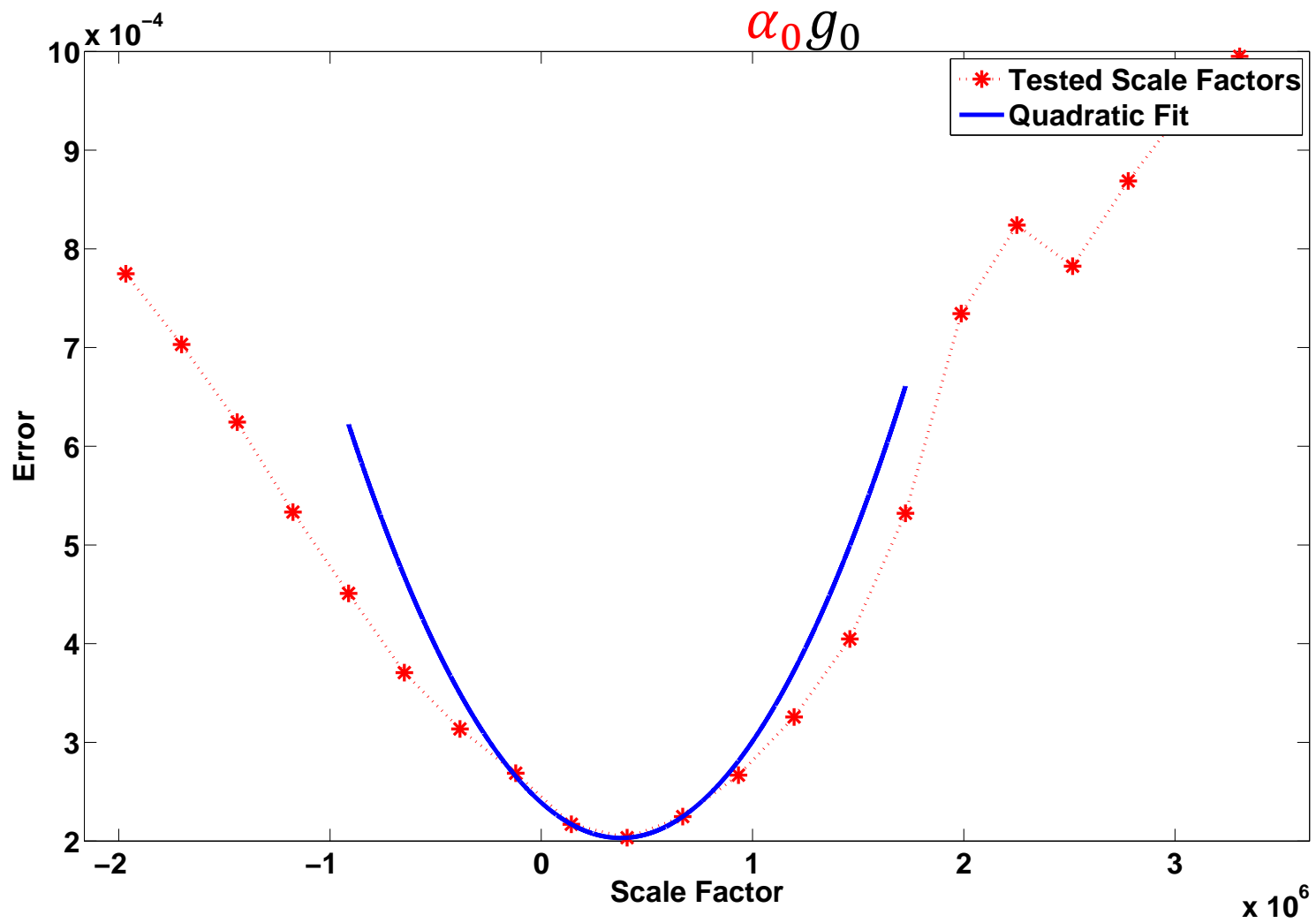
# Introduction

- Iterative
- Gradient

$g_0$



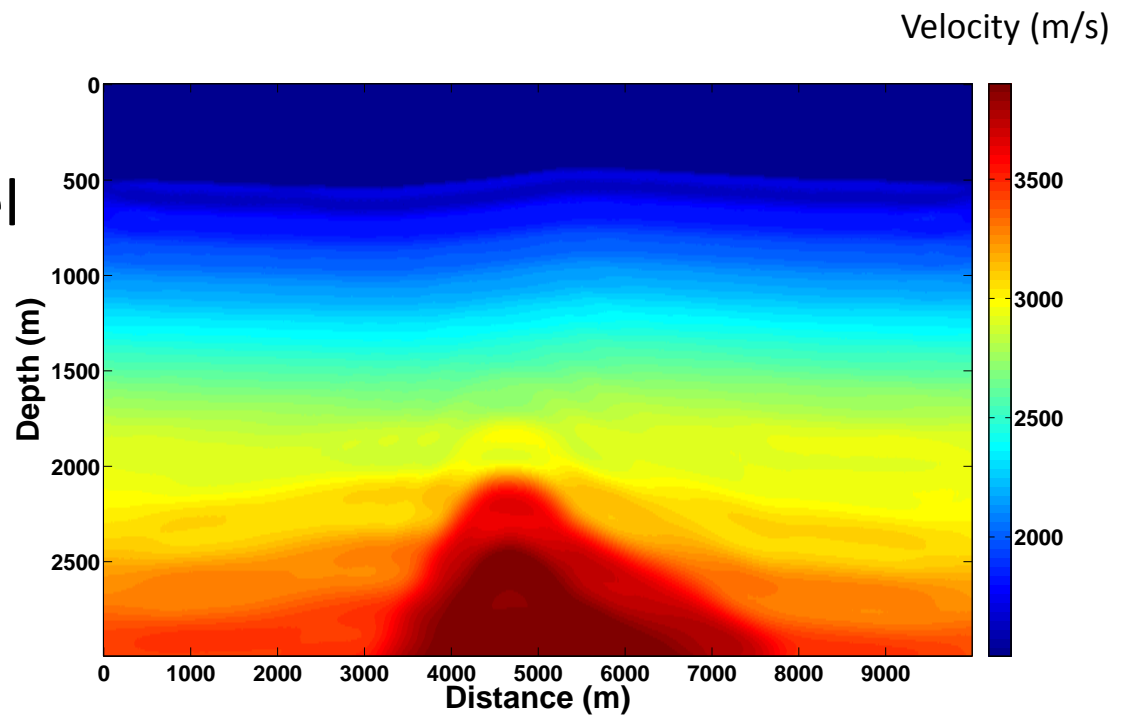
# Introduction



# Introduction

$$m_1 = m_0 + \alpha_0 g_0$$

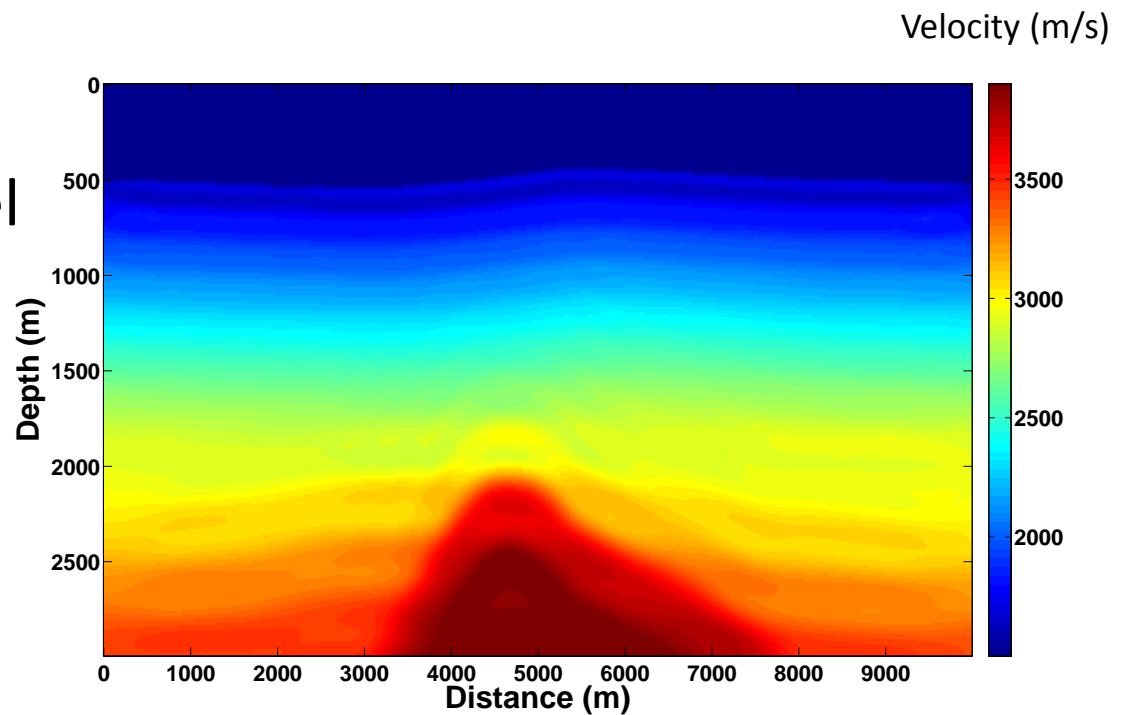
- Iterative
- Gradient
- New velocity model



# Introduction

$$m_2 = m_1 + \alpha_1 g_1$$

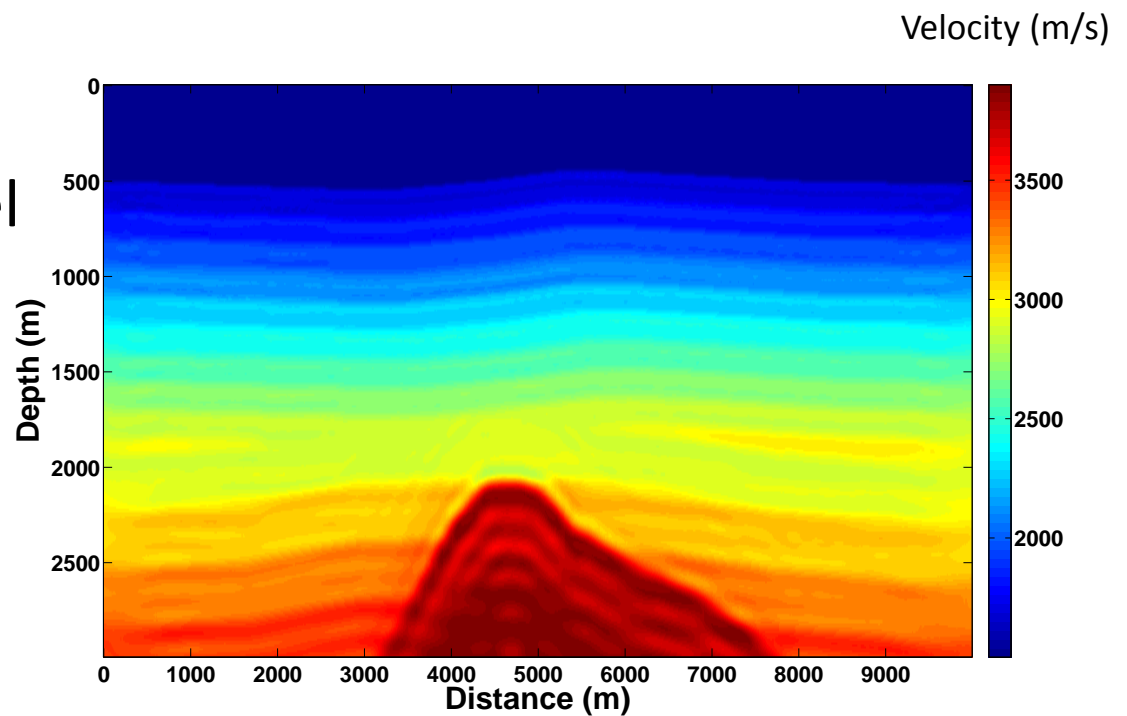
- Iterative
- Gradient
- New velocity model
- Repeat process



# Introduction

$$m_{(n+1)} = m_{(n)} + \alpha_{(n)}g_{(n)}$$

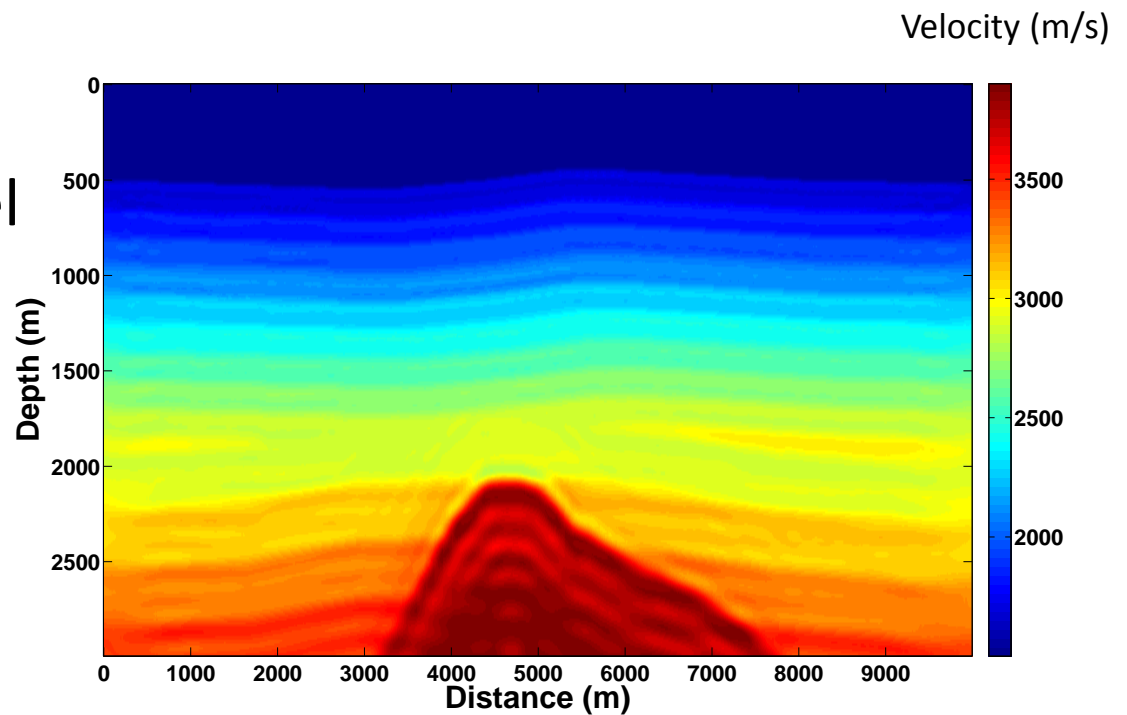
- Iterative
- Gradient
- New velocity model
- Repeat process
- Convergence



# Introduction

$$m_{(n+1)} = m_{(n)} + \alpha_{(n)}g_{(n)}$$

- Iterative
- Gradient
- New velocity model
- Repeat process
- Convergence
- Real model (?)

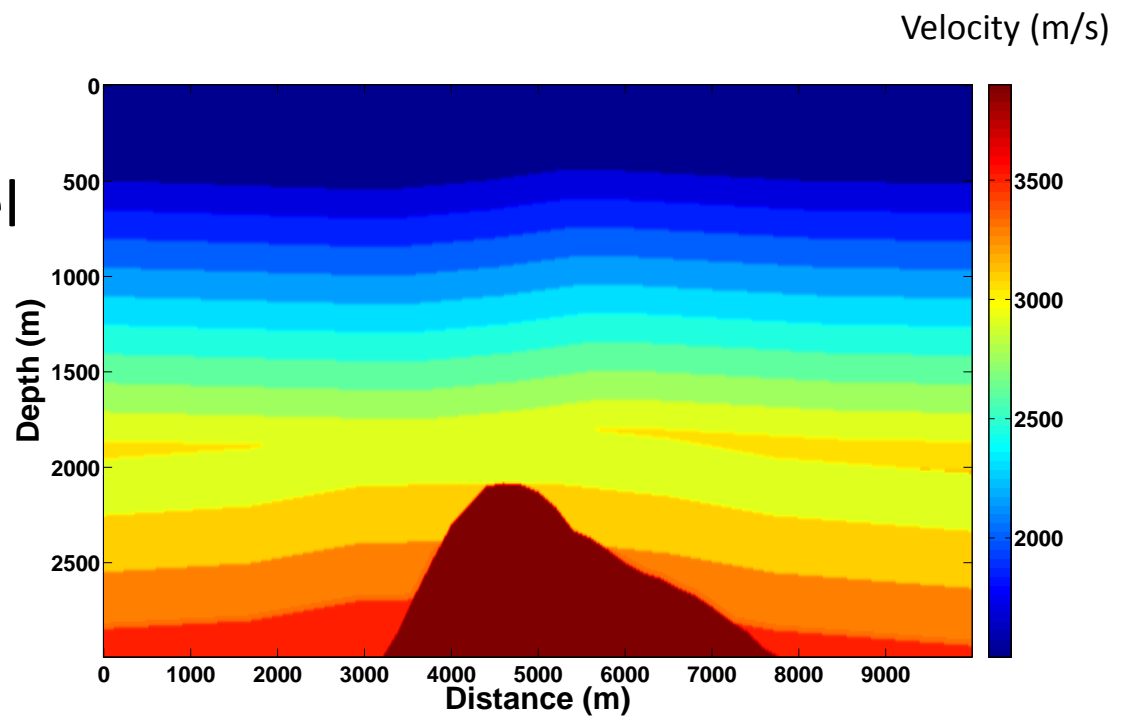


# Introduction

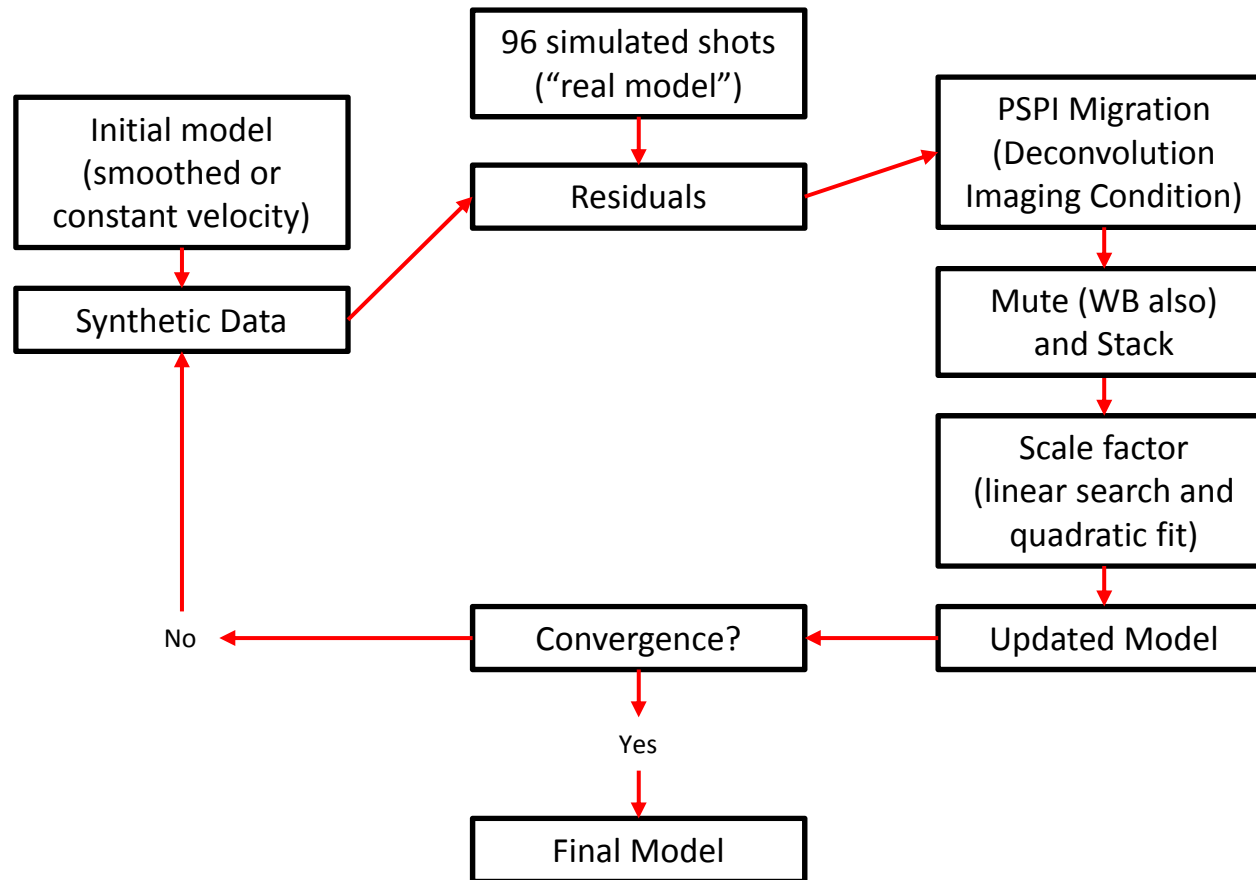
$$m_{(n+1)} \cong m_{real}$$

- Iterative
- Gradient
- New velocity model
- Repeat process
- Convergence
- Real model (?)

**Close...**



# Procedure



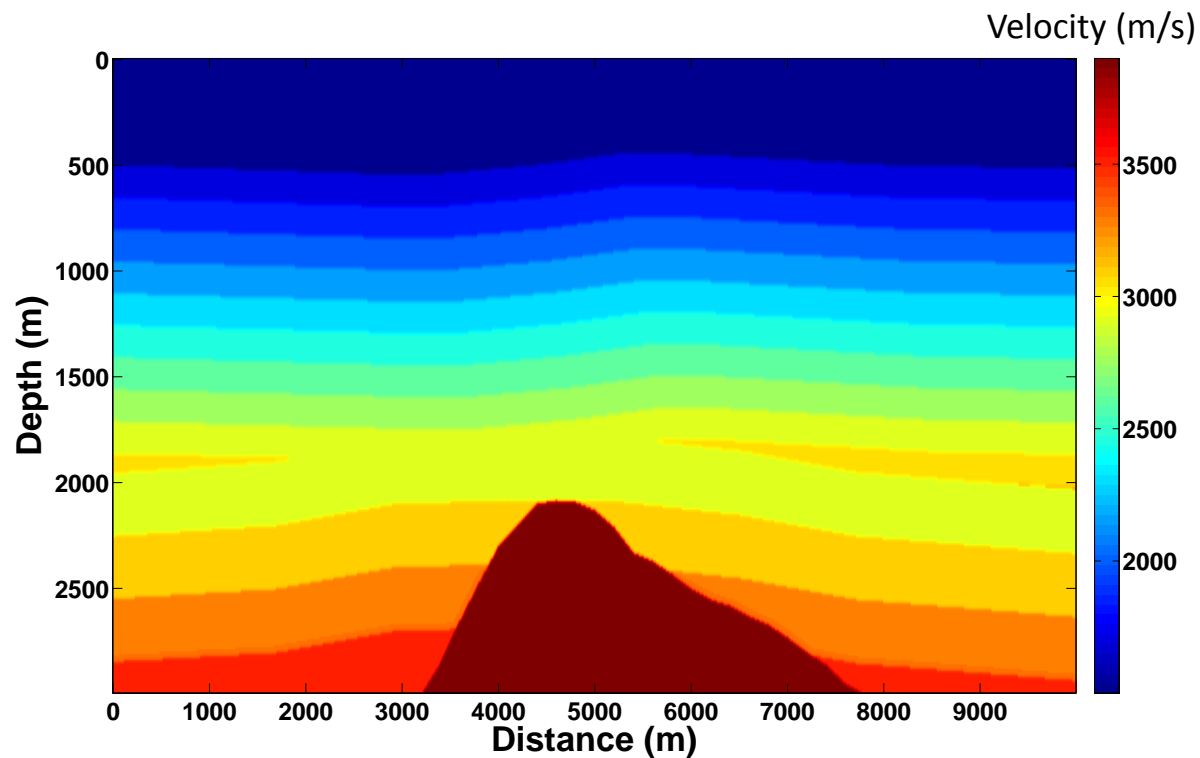


# Synthetic Survey

Acquisition	
Type	Marine
Number of shots	96
Shot spacing	100m
Shot depth	30m
# of receivers	401
Receiver spacing	10m
Receiver depth	0m
Frequency	10Hz

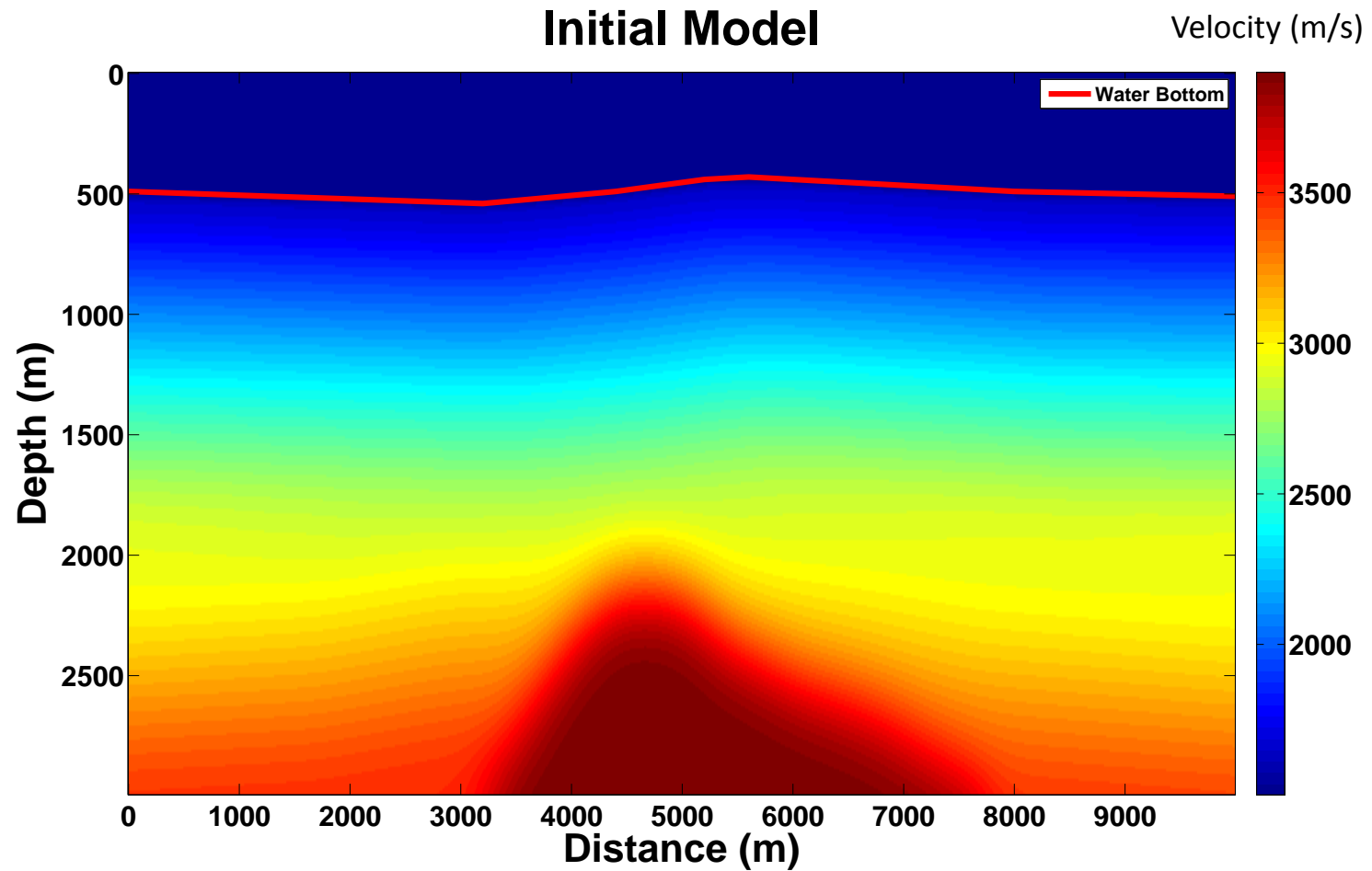
Processing	
Starting frequency	1-6Hz
Iterations per frequency < 16Hz	10
Iterations per frequency > 15Hz	5
Frequency increment < 25Hz	1Hz
Frequency increment > 24Hz	5Hz
Mute	Yes
Water bottom mute	Yes
Scale factor tests	21

# Synthetic Survey – Velocity Model

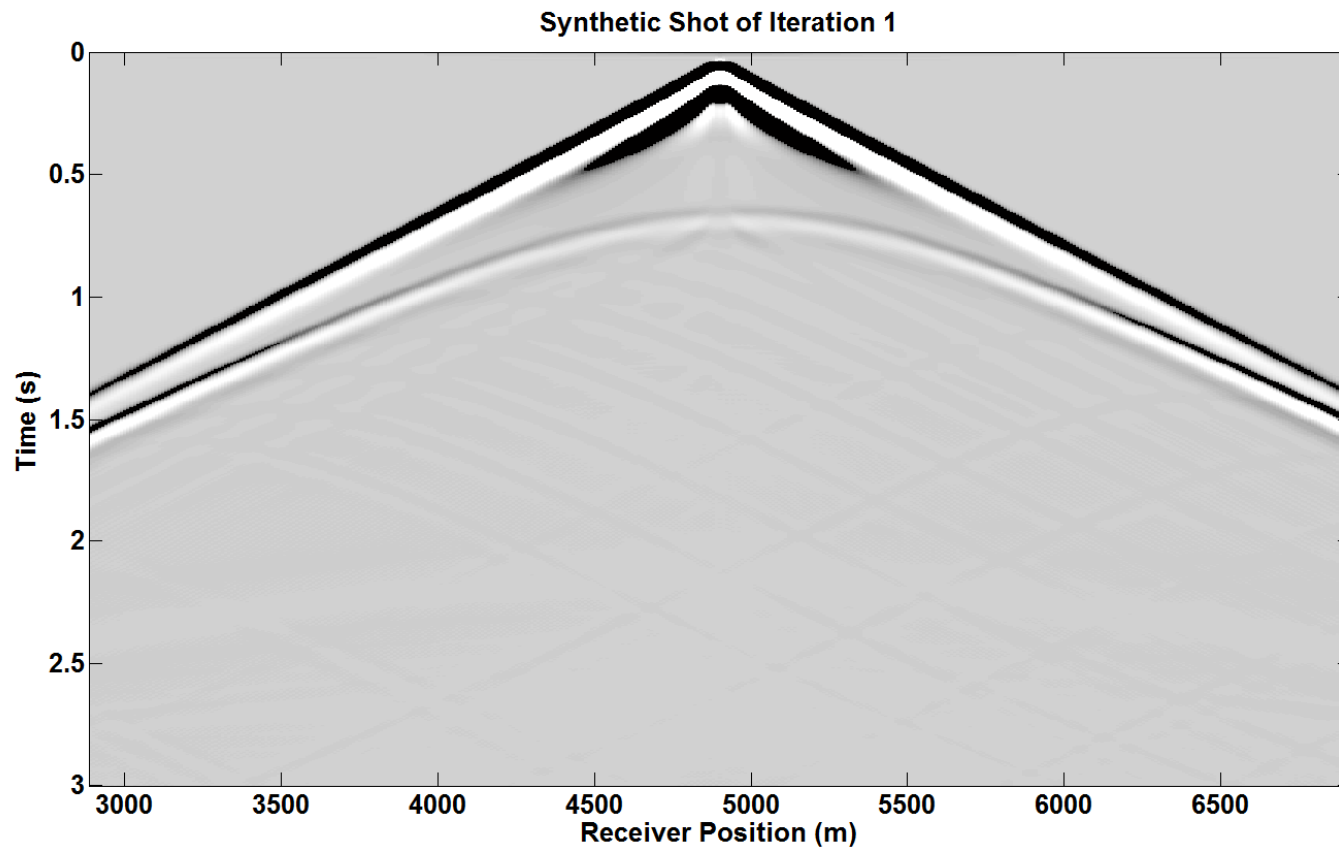


Model	
Depth	3km
Width	10km
Resolution	10m
Min. velocity	1500m/s
Max. velocity	3900m/s

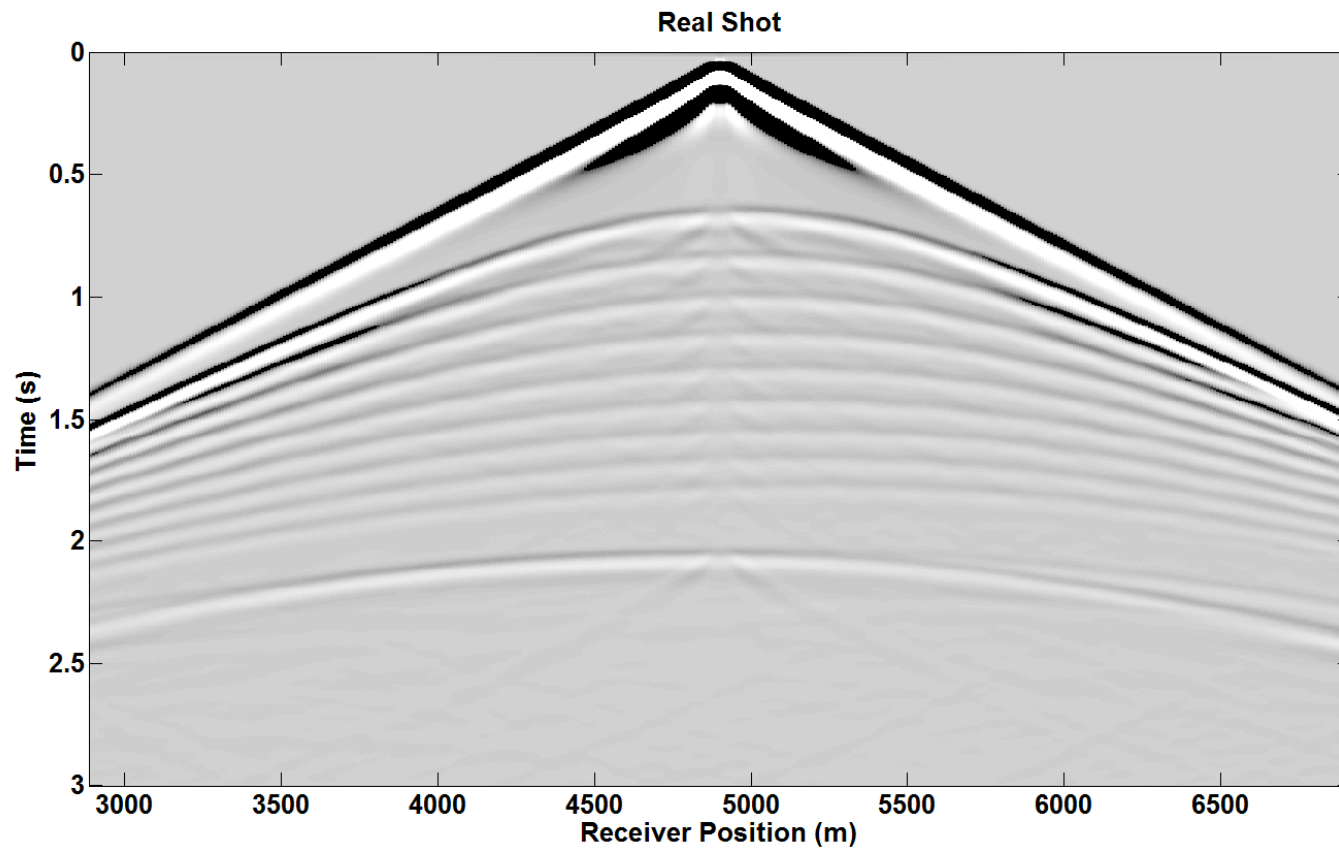
# Initial Model



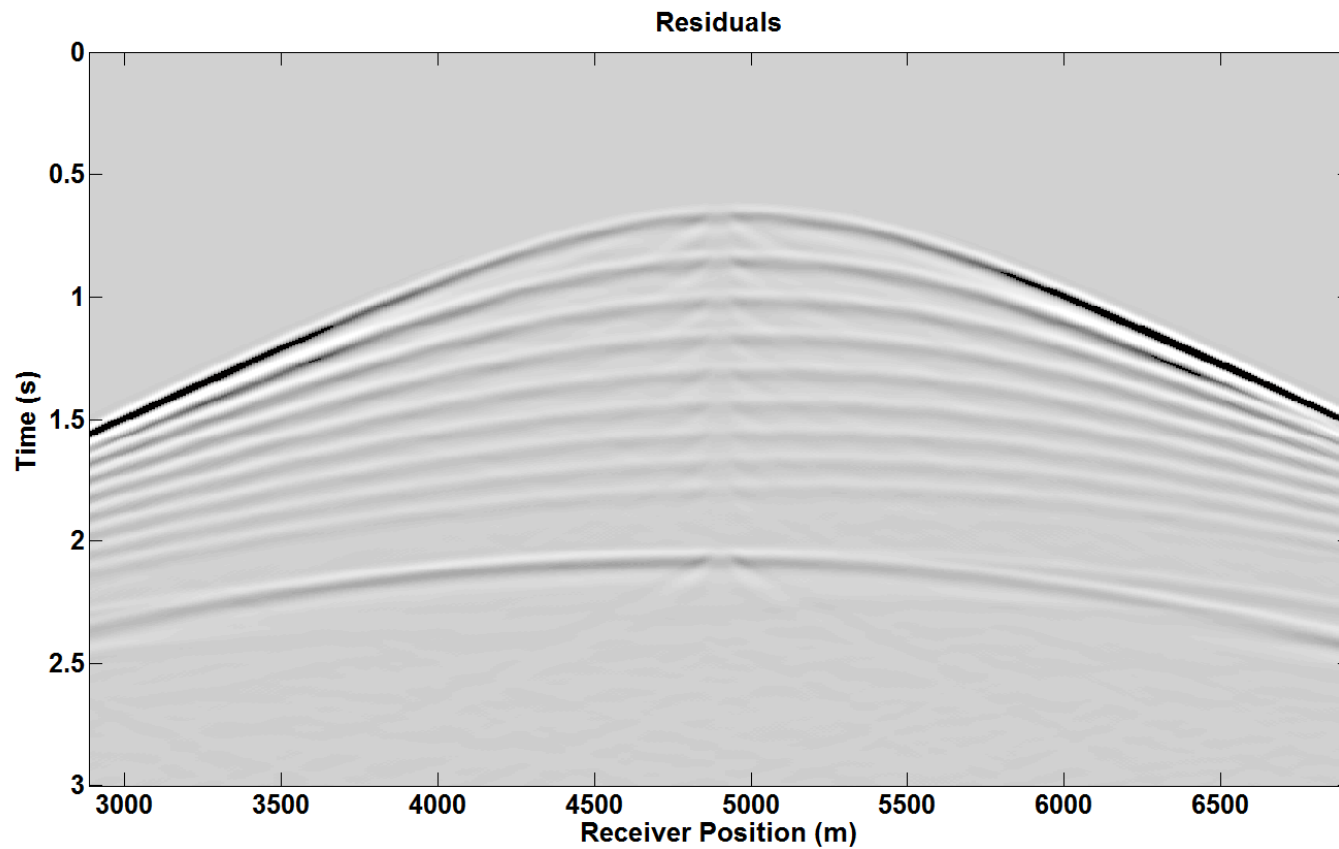
# Synthetic Shot



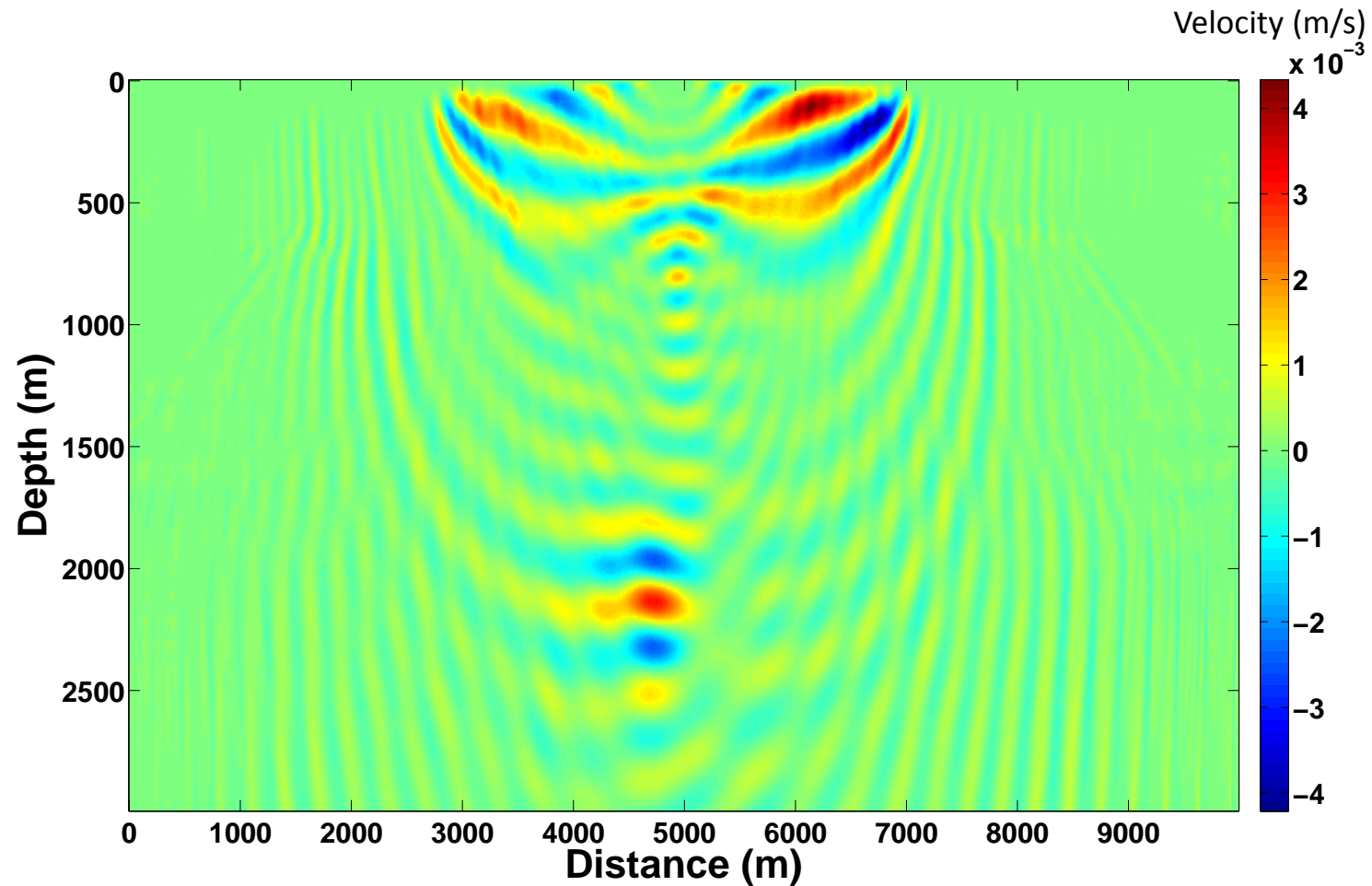
# Real Shot



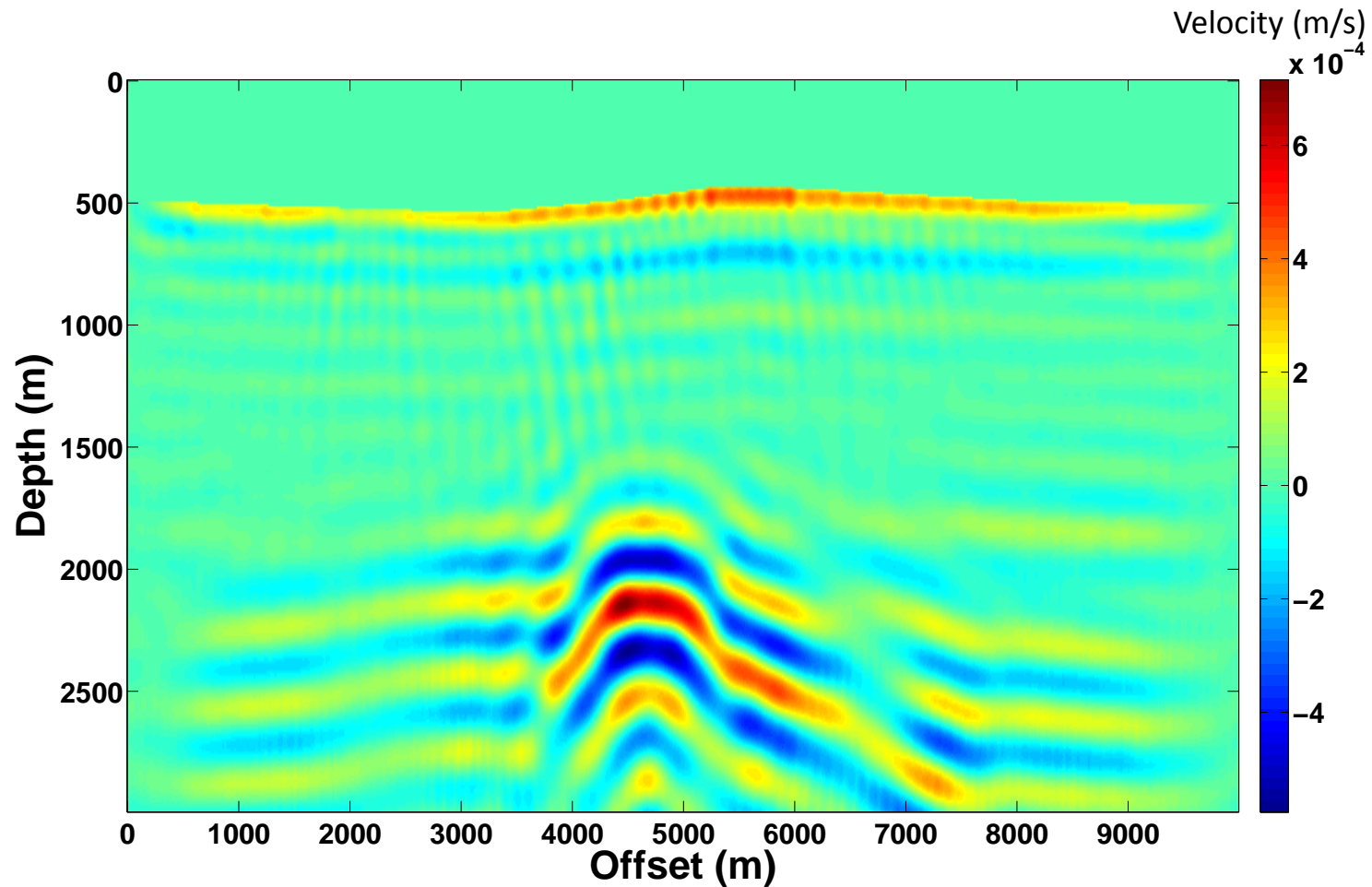
# Residuals (first iteration)



# Migrated Residuals

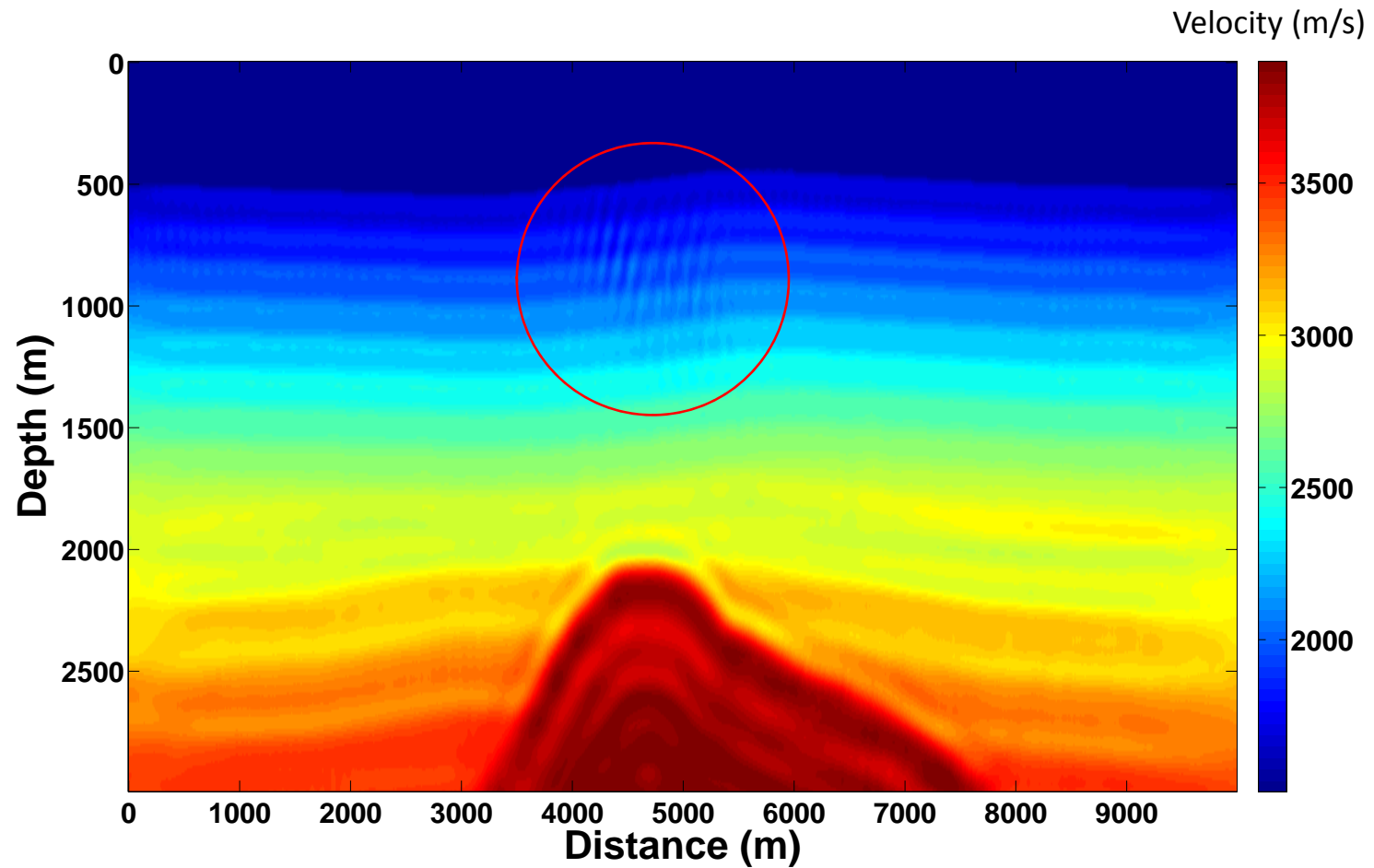


# Stacked Migrated Residuals– Iteration 1

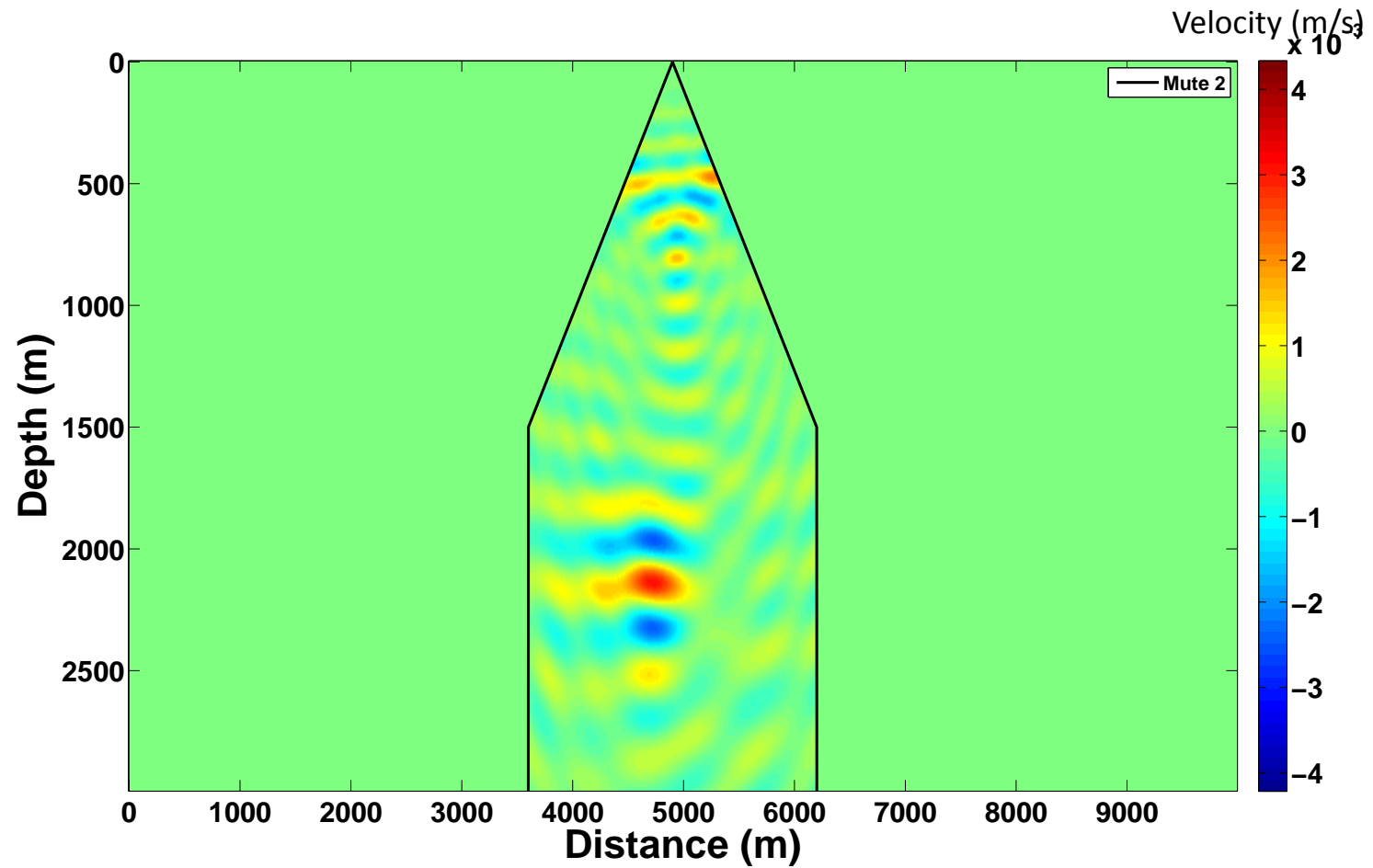




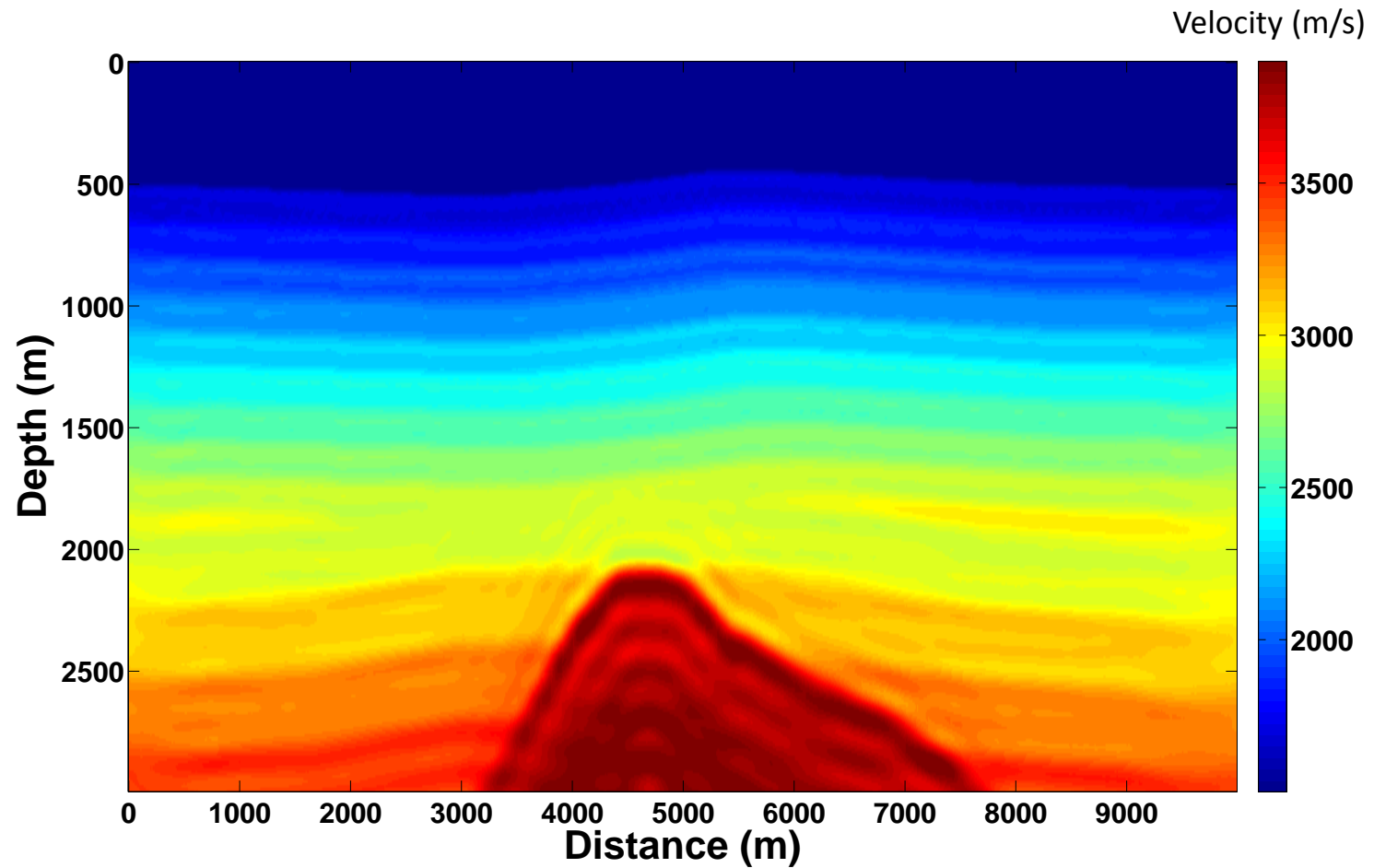
# Iteration 79 (1 – 13 Hz)



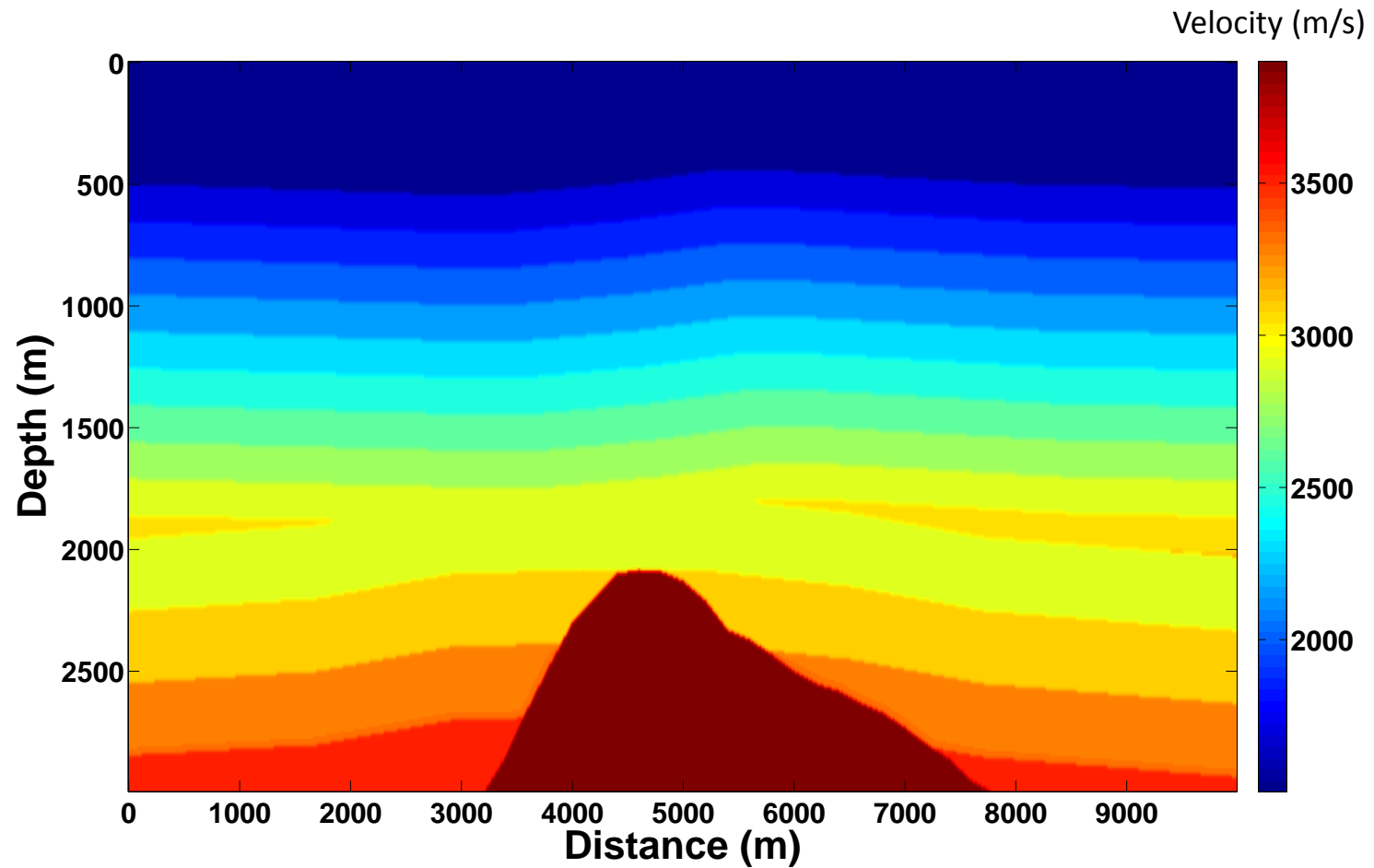
# Migrated Residuals



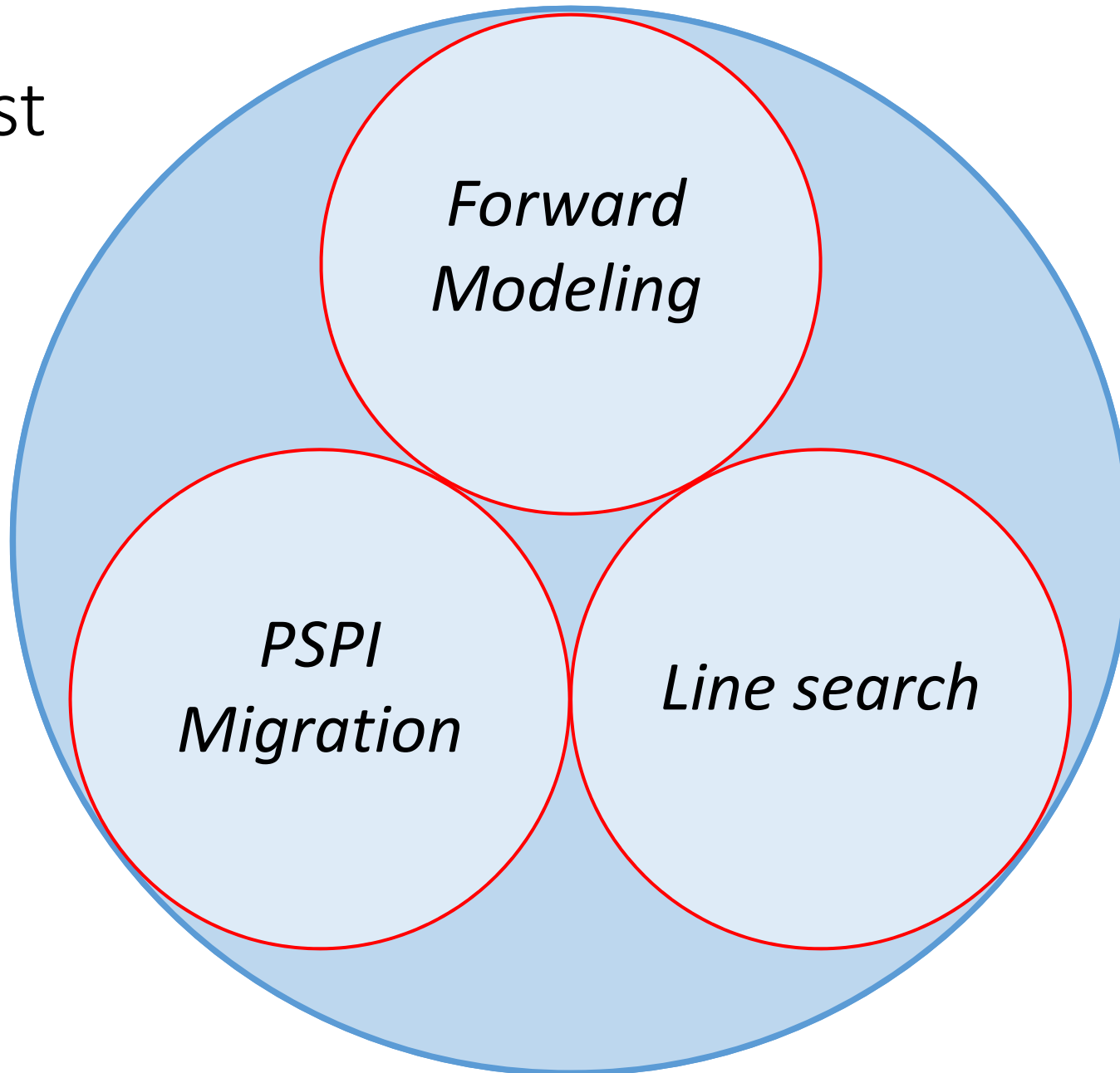
# Iteration 60 (1 – 12 Hz) - Muted



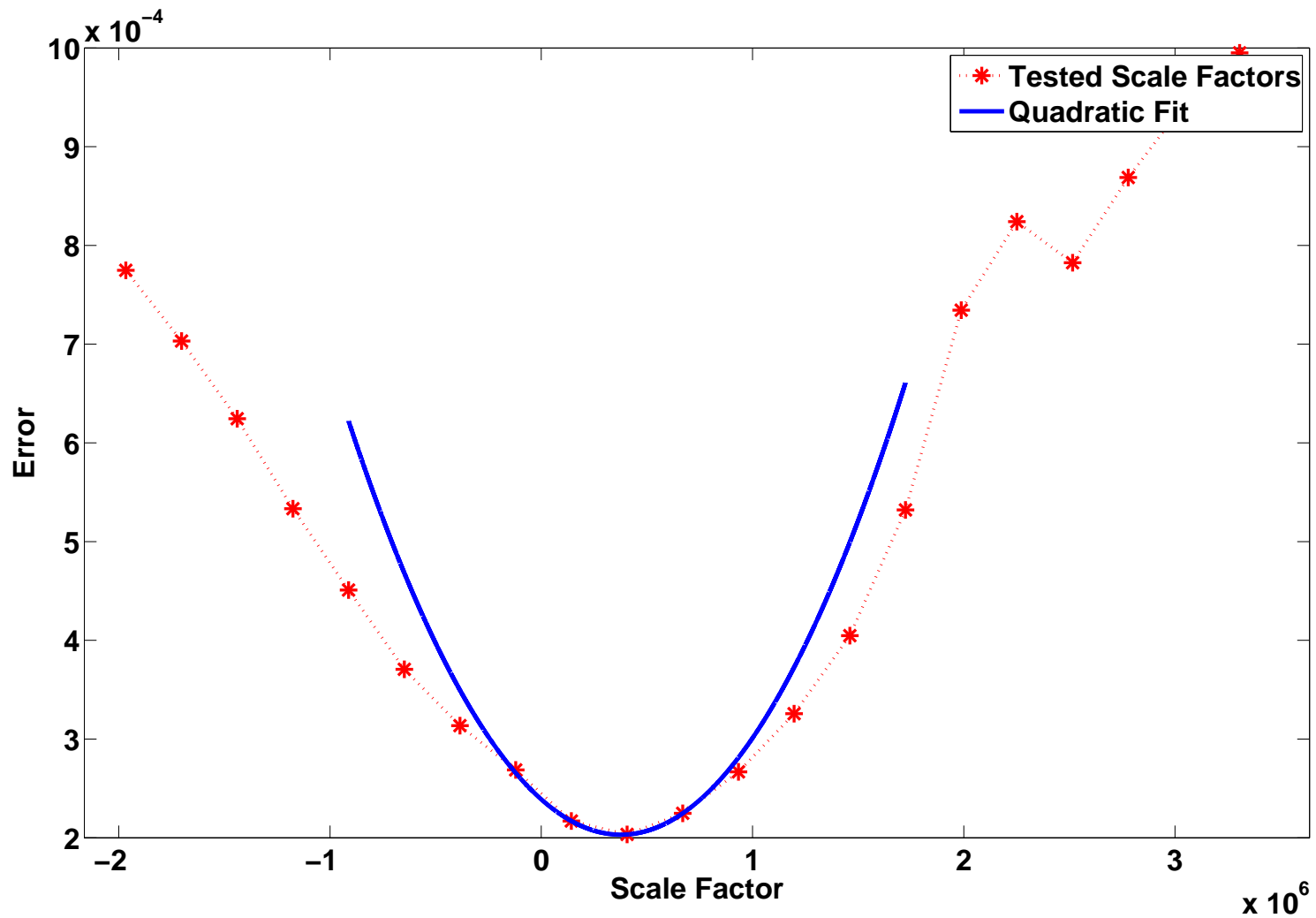
# Real Model



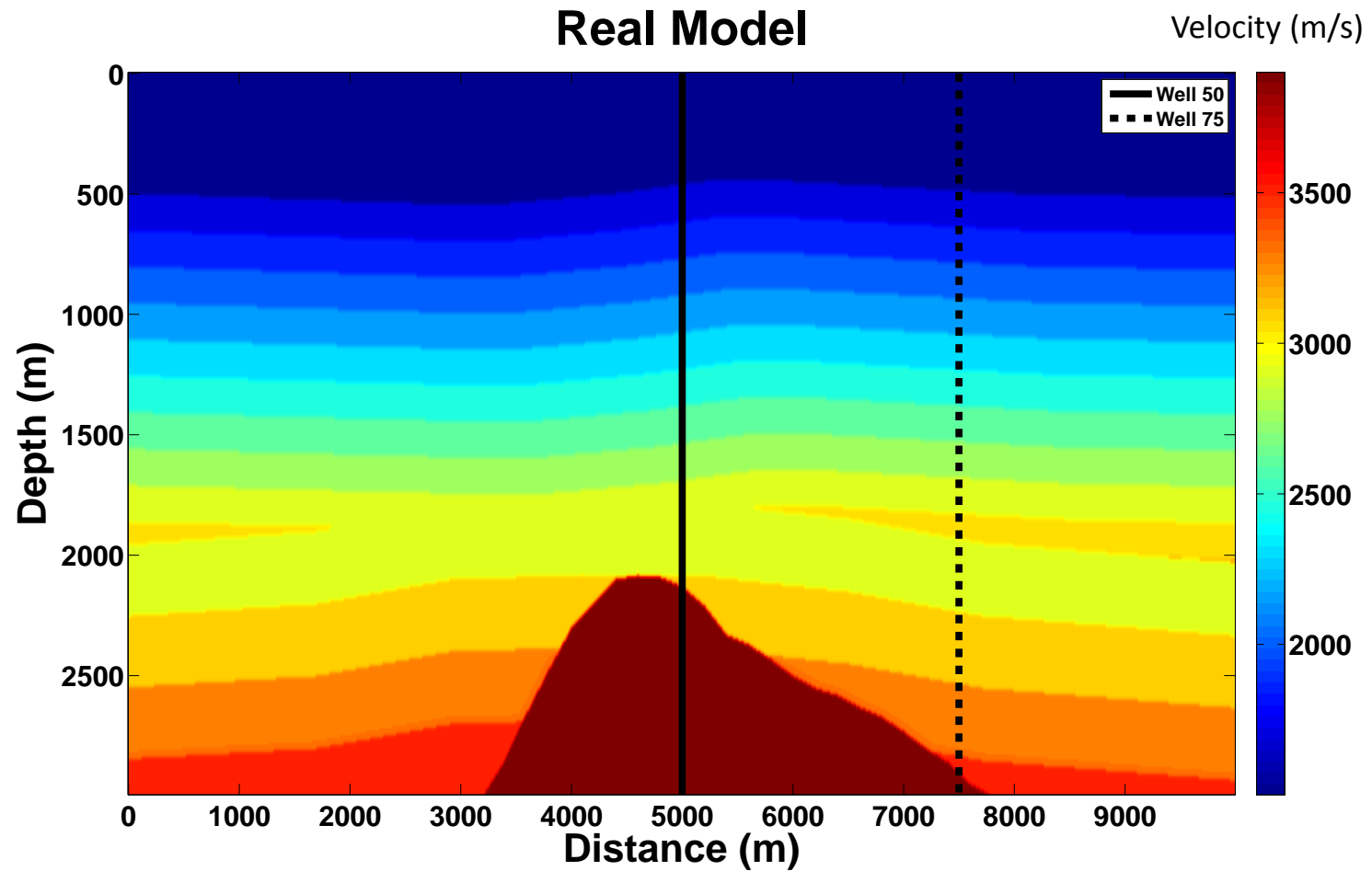
Cost



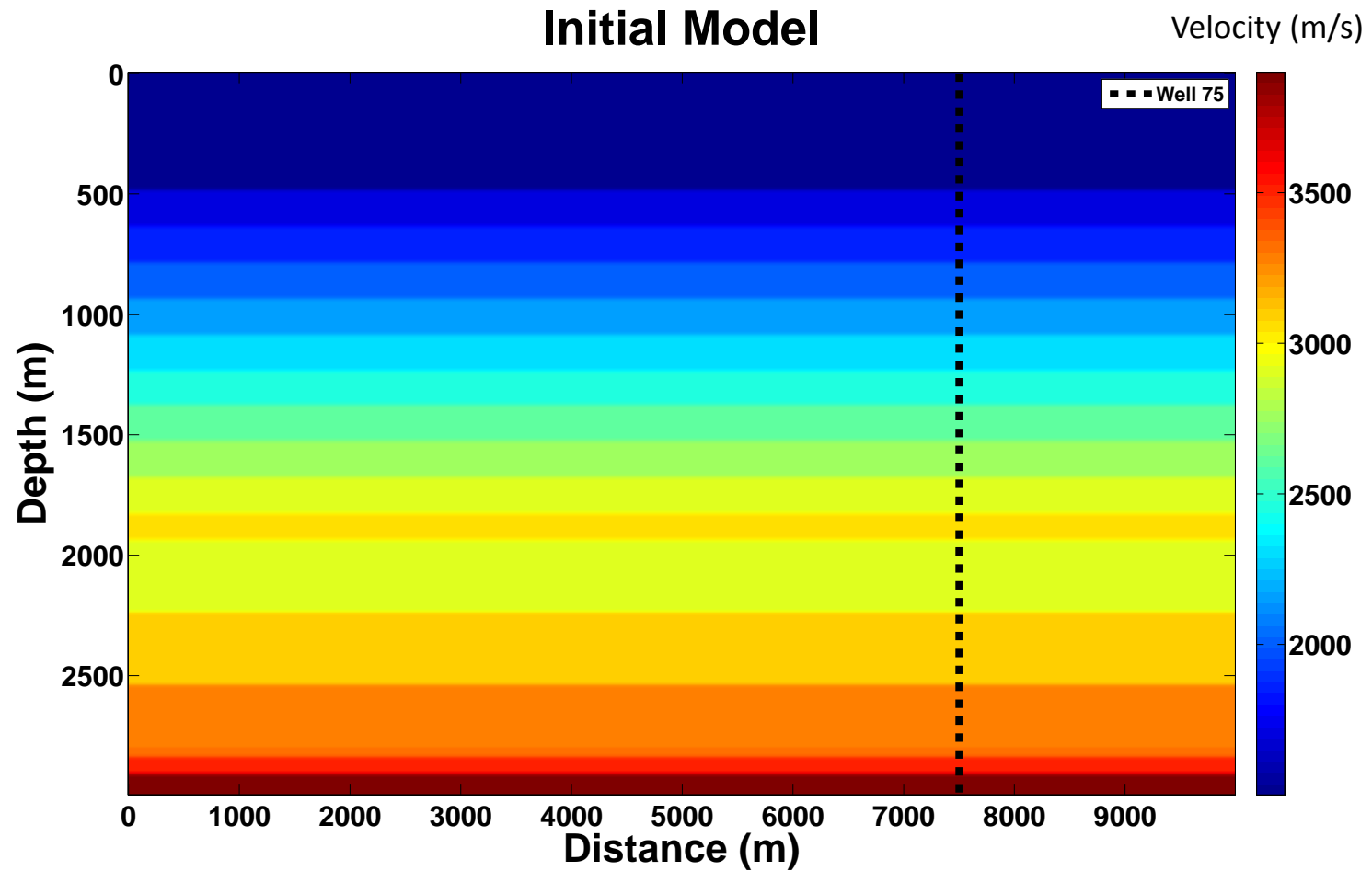
# Cost - Line search



# Real Model

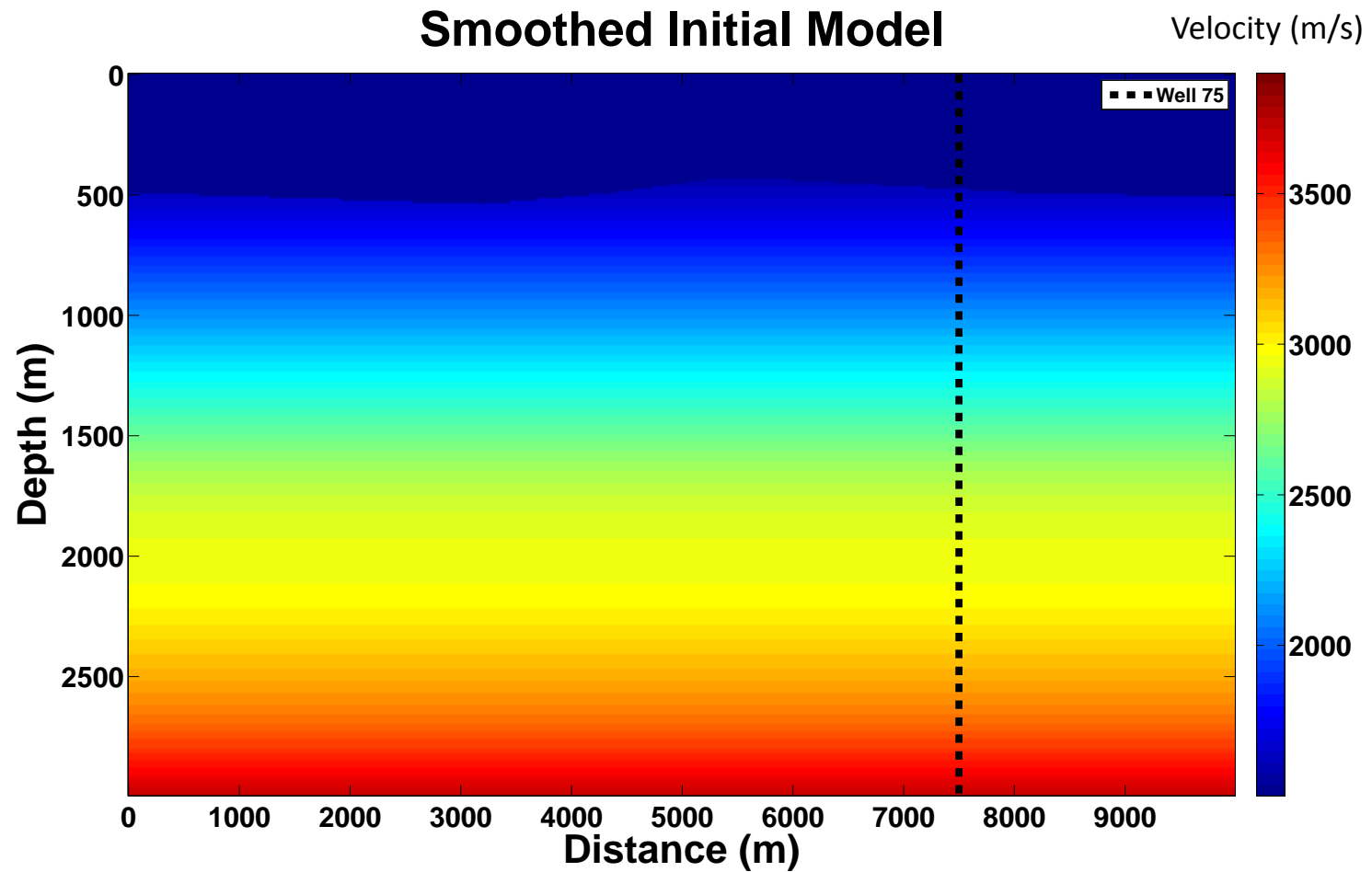


# Initial Model



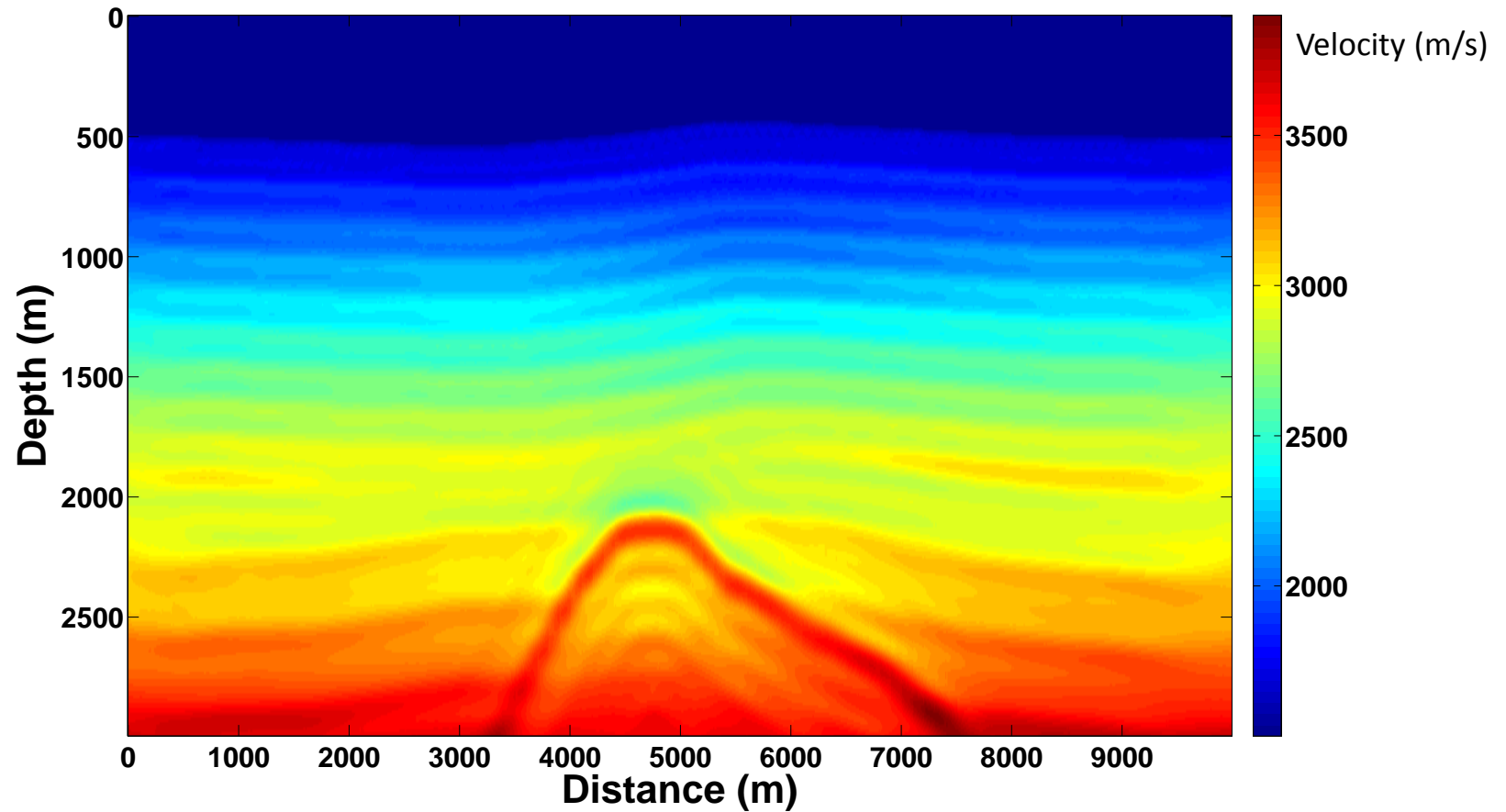


# Initial Model

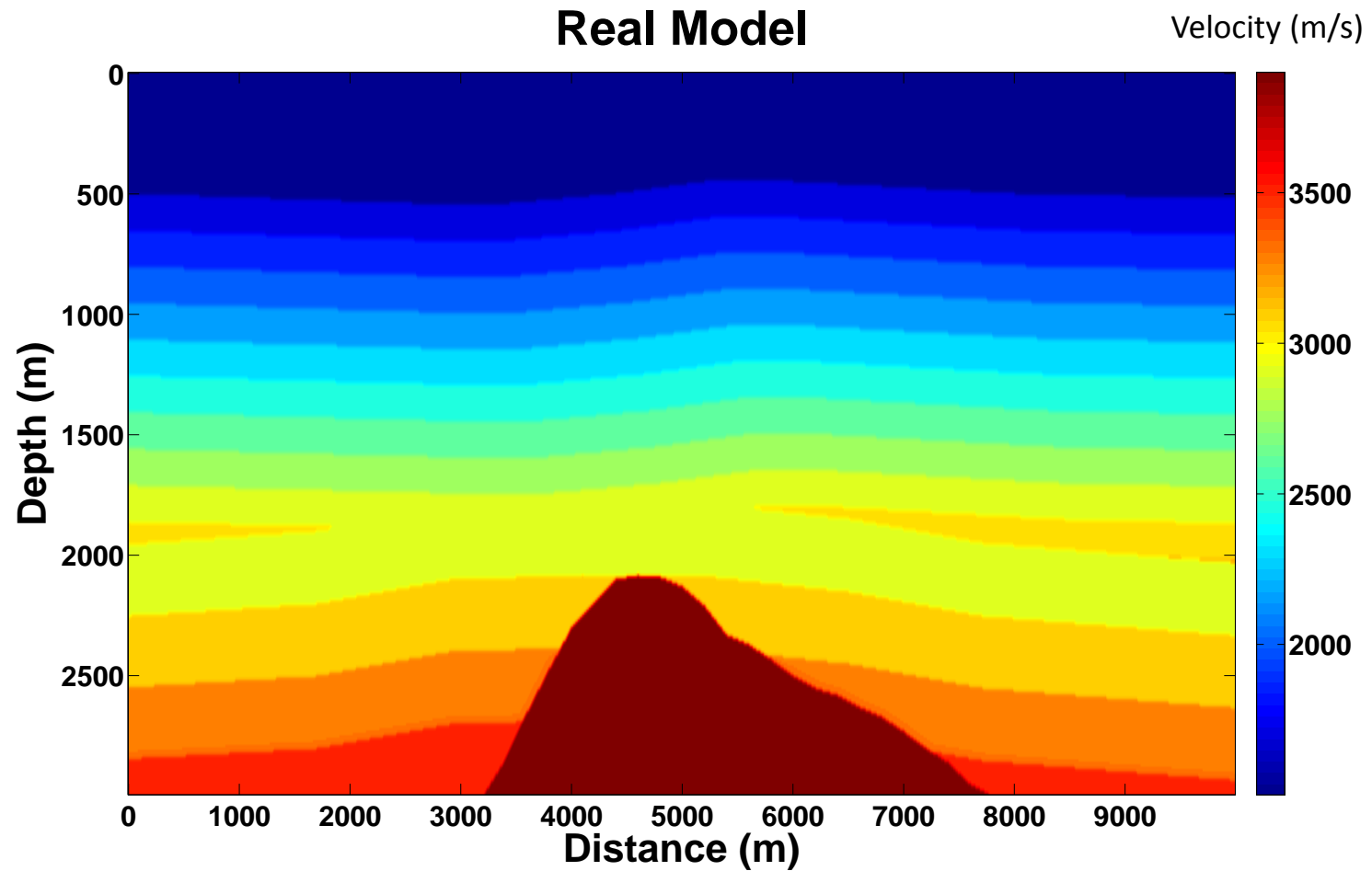


# Best Fit

Iteration 55 (1 – 11 Hz) – Well 75 as Initial Velocity Model



# Real Model

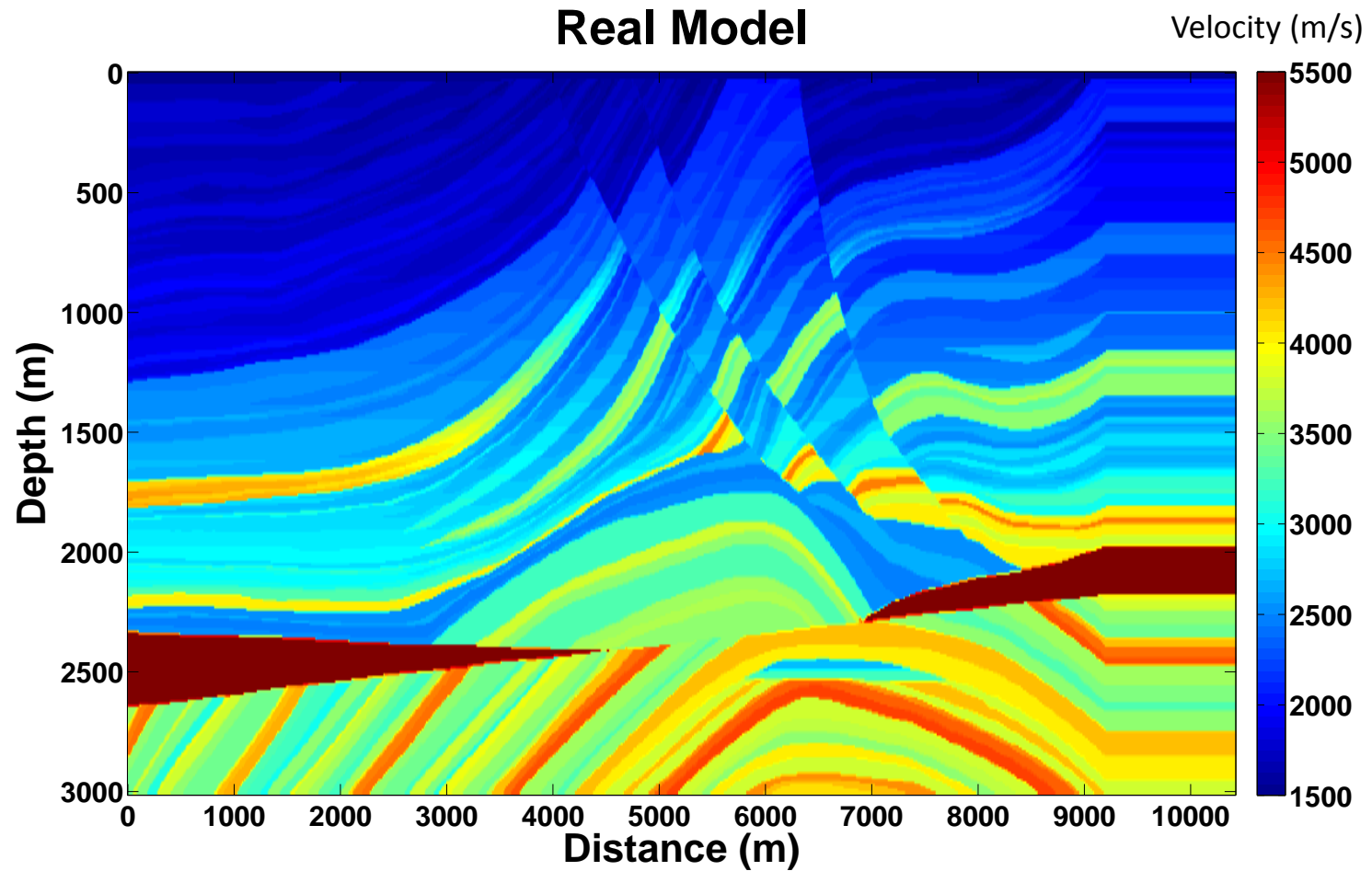


# Synthetic Survey - Marmousi

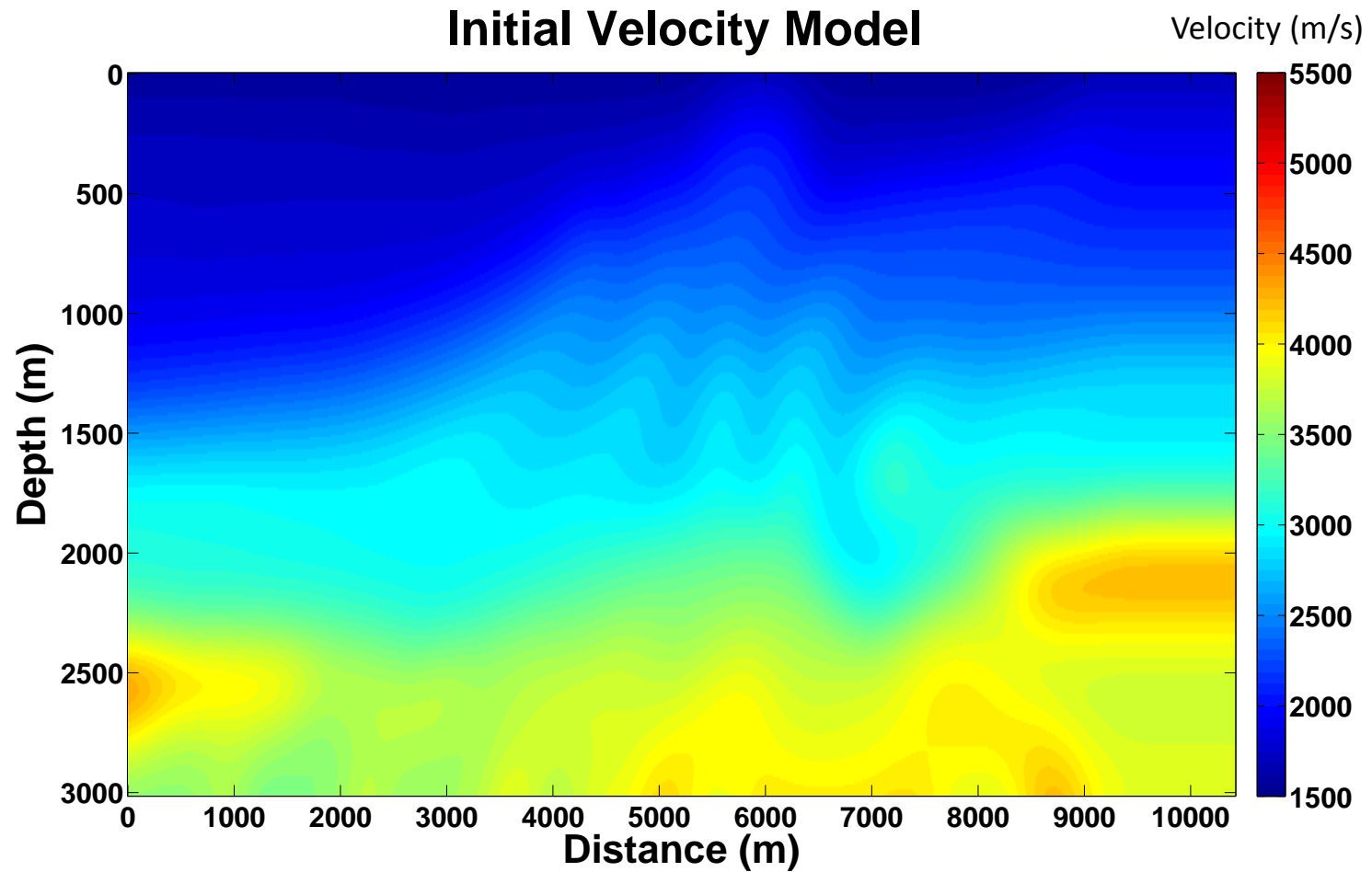
Acquisition	
Model	Marmousi
Number of shots	101
Shot spacing	100m
Shot depth	0m
# of receivers	401
Receiver spacing	10m
Receiver depth	0m
Frequency	10Hz

Processing	
Starting frequency	1-4Hz
Iterations per frequency < 13Hz	5
Iterations per frequency > 12Hz	2
Frequency increment < 13Hz	1Hz
Frequency increment > 12Hz	5Hz
Mute	Yes
Smooth	Yes
Scale factor tests	21

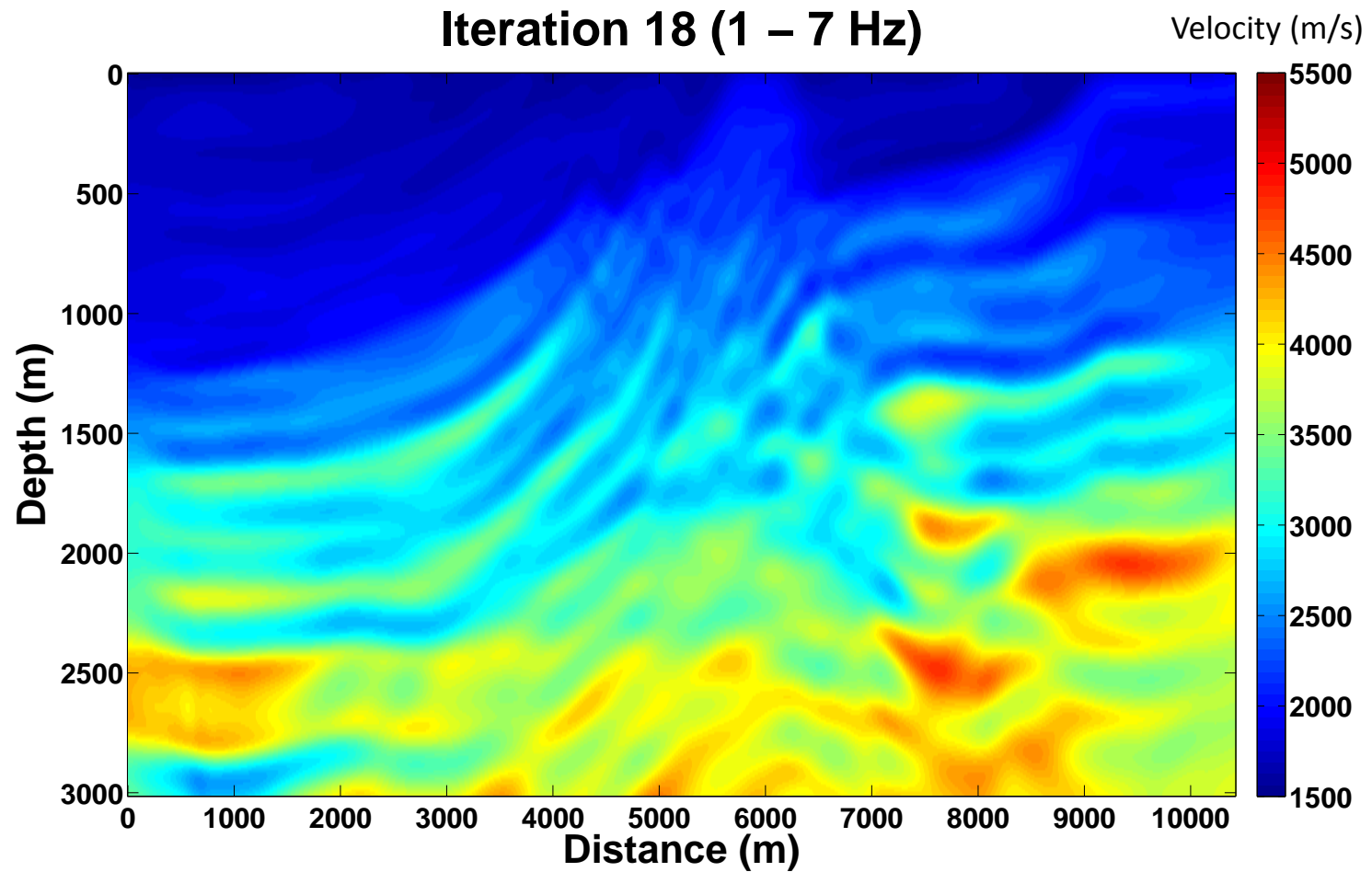
# Marmousi



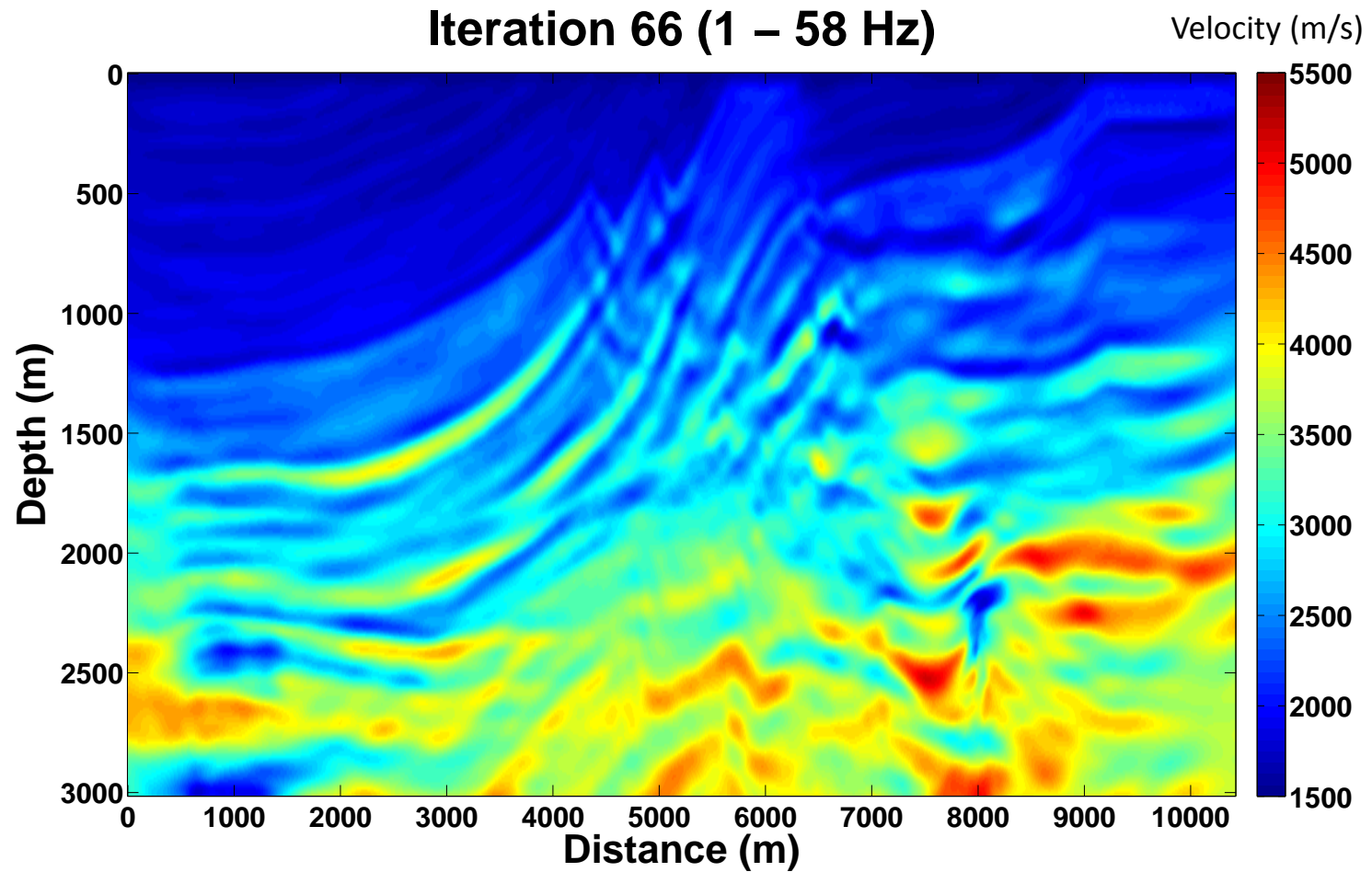
# Initial Model



# Iteration 18

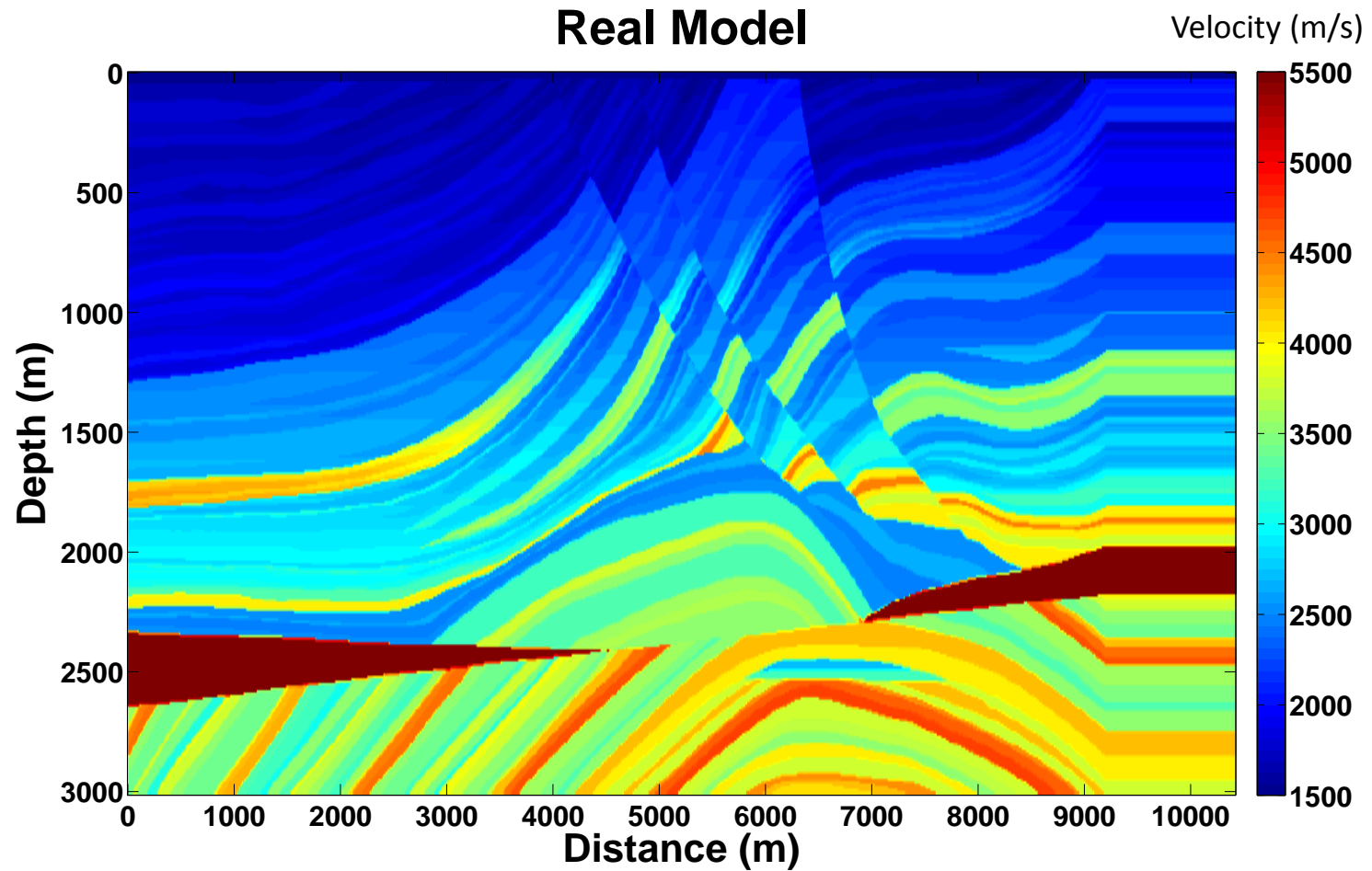


# Iteration 66





# Marmousi



## Conclusions

- Computational Cost – HIGH
- Artifacts
- Starting model – good results for “poor” starting model

## Future

- Interpolated sonic logs as starting model
- Improve line search
- Well tie for scale factor and cycle skipping
- Deconvolution imaging condition – wavelet

# Acknowledgements

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- Staff members and colleagues