Tomographic Imaging of the Blind Test Dataset

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Outline

- Forward Modeling
- Inversion Approach
- Results
- Comparison with Different Parameters
- Conclusion

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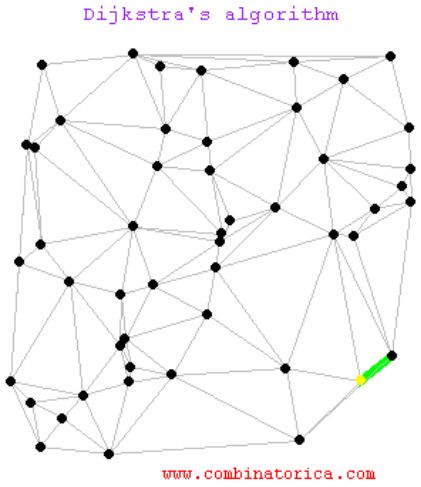
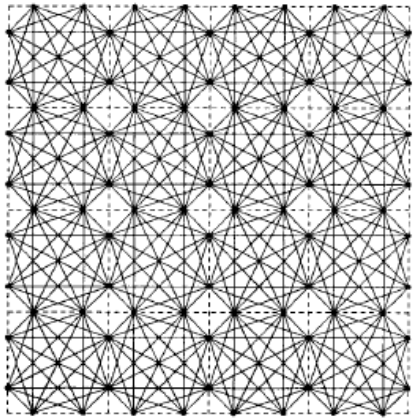
Forward Modeling

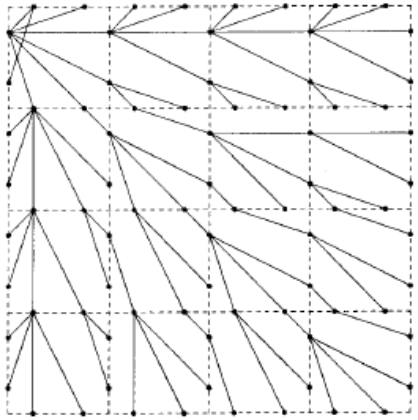
Graph Method (Shortest Path):

based on network theory to calculate the shortest connections from a node to all other nodes in a network



Forward Modeling (Cont'd)





Moser (1991)

Advantages of Graph Method

- Robust to handle any complex velocity structure
- Complete convergence
- Accuracy is quadratically dependent upon the number of nodes and order of forward star
- Calculate the seismic ray paths from a shot to all receivers simultaneously
- A good implementation can be very efficient

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Inversion Approach

For a set of refraction travel time, the inverse problem can be represented as follows:

$$d = Gm$$

Where, d is the travel time vector, G is Frechet derivative matrix, and m is the unknown model.

Inverse Approach (Cont'd)

Equation $d = Gm$ is ill-conditioned, a standard least squares solution is inapplicable.

Regularized inversion is employed, i.e., to stabilize solution, apply constraints

$$d = C_d^{1/2}(C_d^{-1/2} G C_m^{-1/2} + \lambda L_h + \lambda L_v + \alpha D) C_m^{-1/2} m$$

Where C_d is the data covariance matrix , C_m is the model scaling matrix, L_v and L_h are the smoothing matrices, D is damping matrix, and λ, α are weighting factors.

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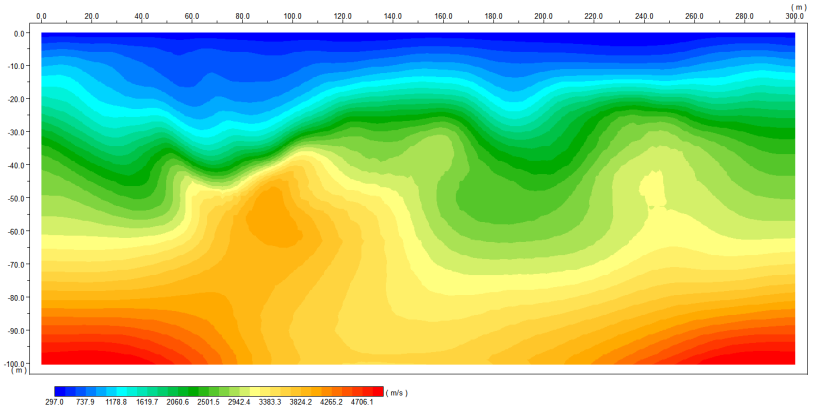
Results: Final Model

Parameters

Grid: 1.5mx1.5m
Order: 5x5
Smoother: 7.5mx7.5m
Picking error: 1ms
Iterations: 10



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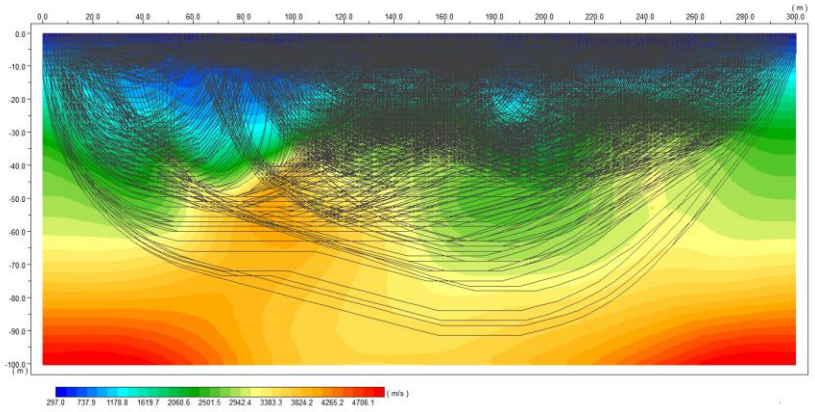
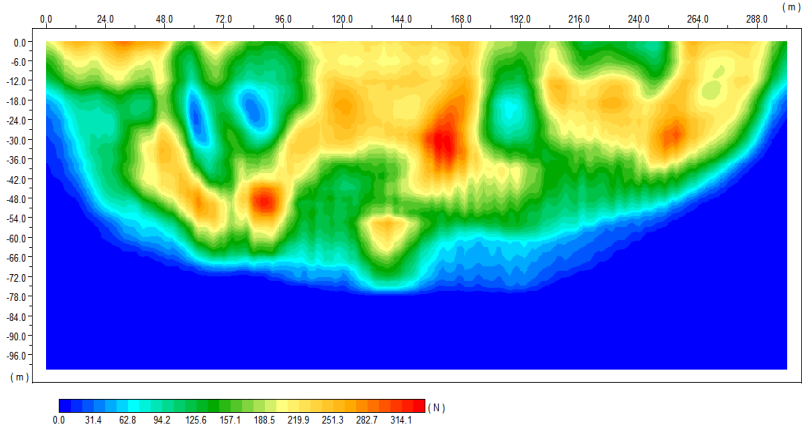
Results: Ray Coverage

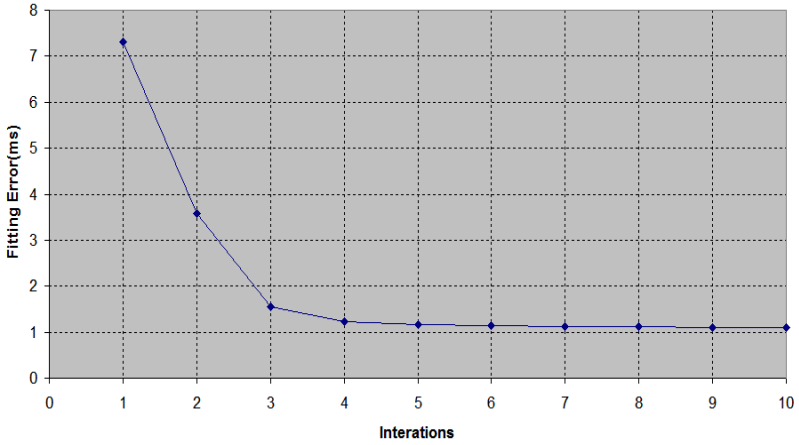
Ray of All Shots



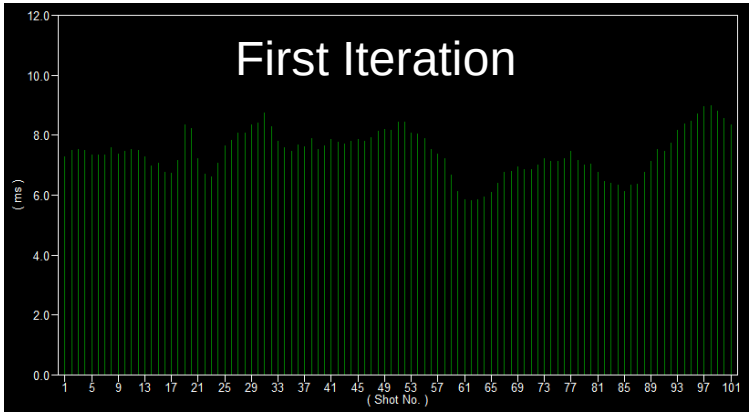
Hit Count

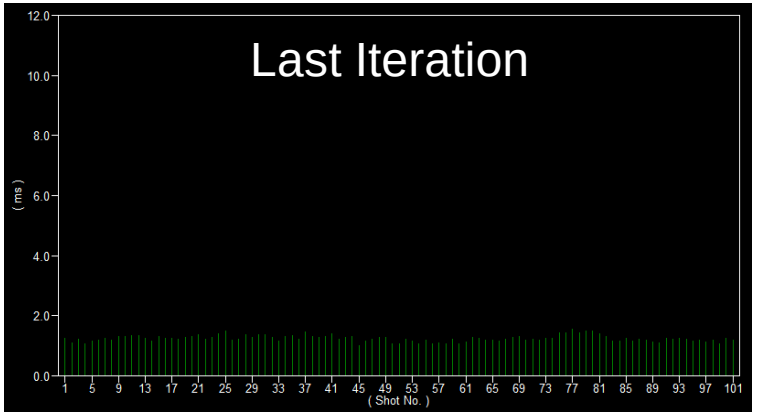


Results: Fitting Error



Misfit of Each Iteration





Misfit of Each Shot

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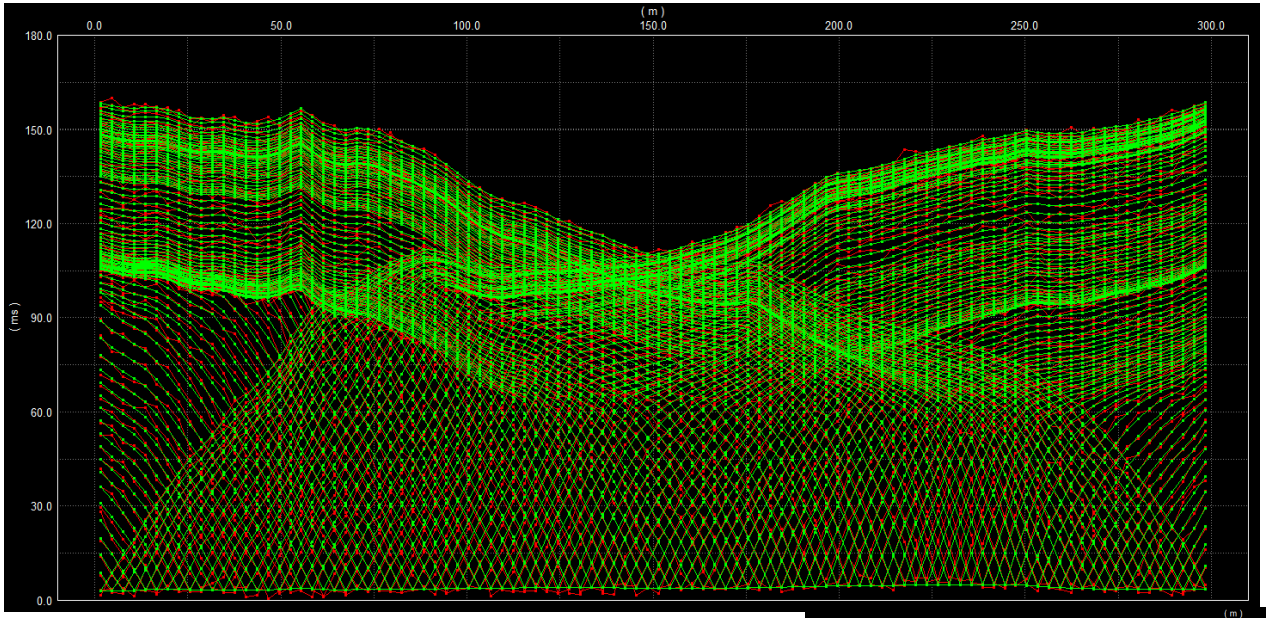
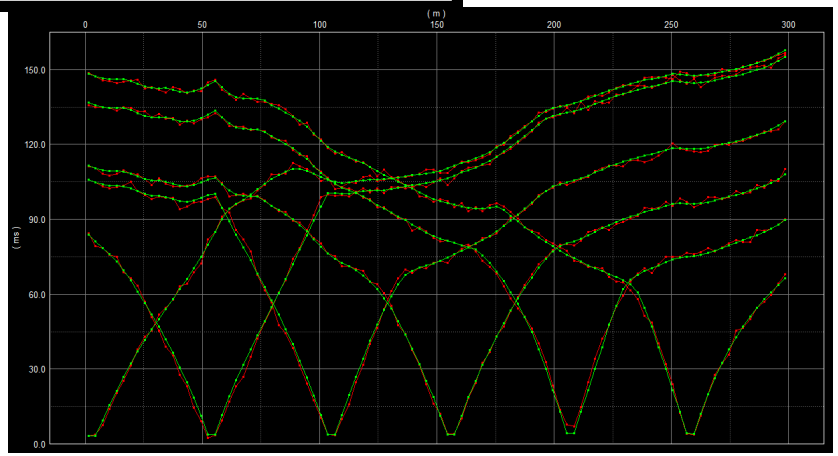
Results: Travel Time Curve Fitting





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Results: CPU Timing

Grid: 1.5mx1.5m (Cells:200x100)

Iterations: 10

Timing: 209s, 21s/Iteration

CPU: Intel Core i5 (2.67GHz)

Thread: single

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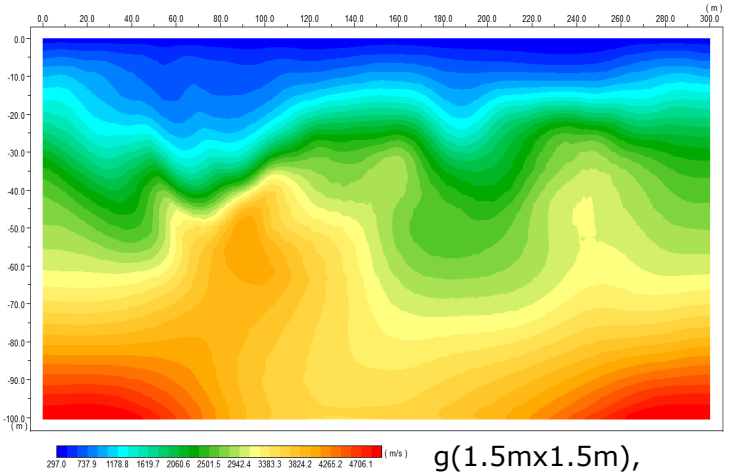
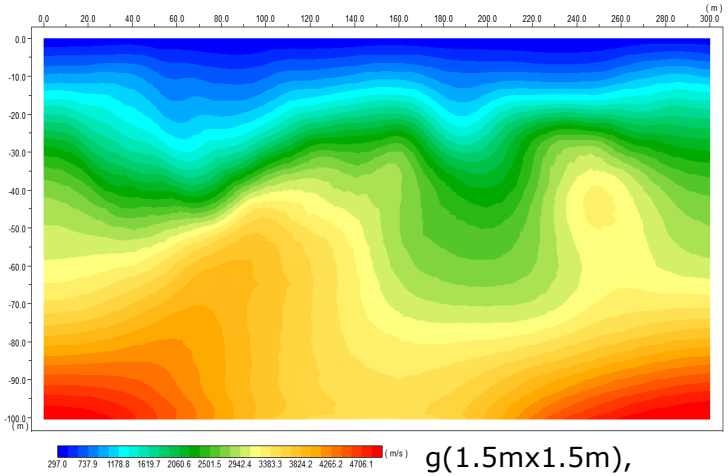
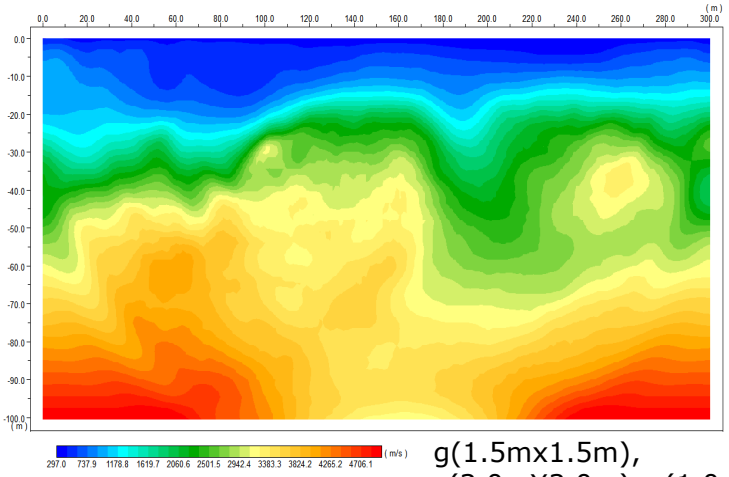
Comparison: Grid, Smoother, Picking Error



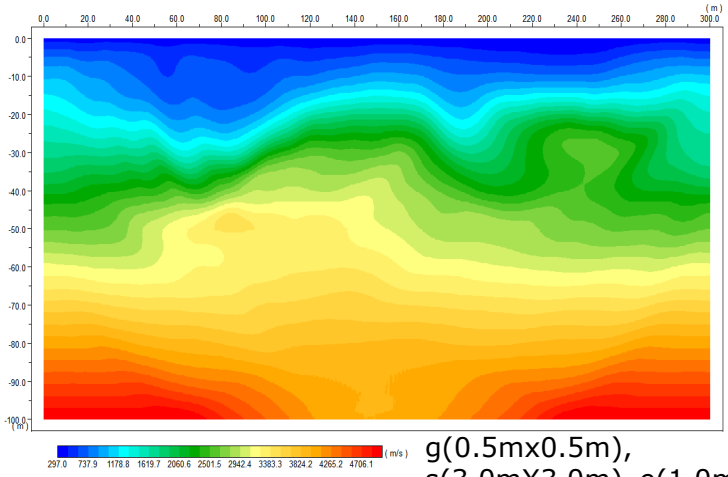
g(1.5mx1.5m), s(7.5mX7.5m), e(1.0ms)



g(1.5mx1.5m), s(7.5mX7.5m), e(0.5ms)

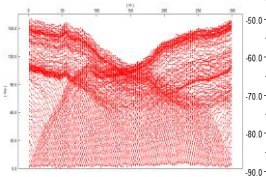


g(1.5mx1.5m), s(3.0mX3.0m), e(1.0ms)



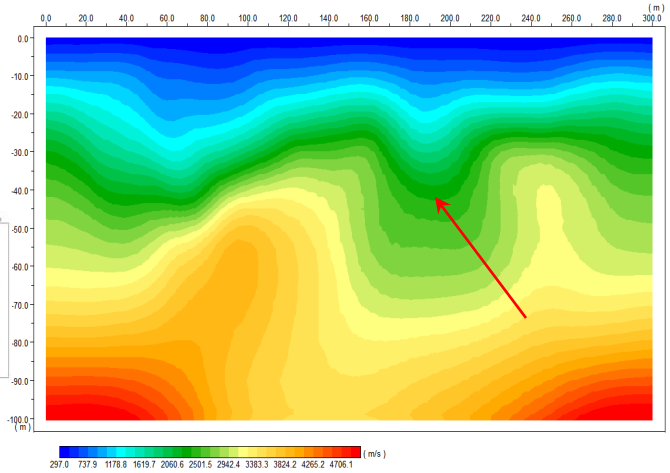
g(0.5mx0.5m), s(3.0mX3.0m), e(1.0ms)

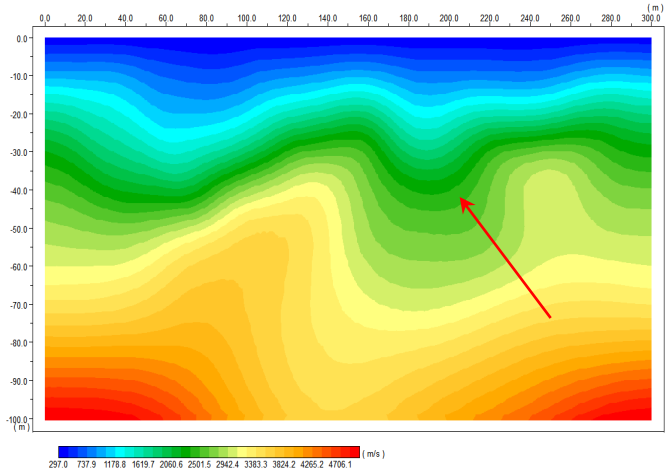
Comparison: Sparse Shots

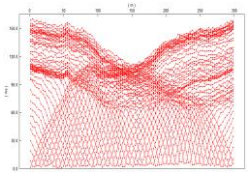


101shots

Error: 1.716ms

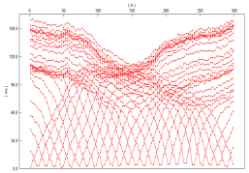






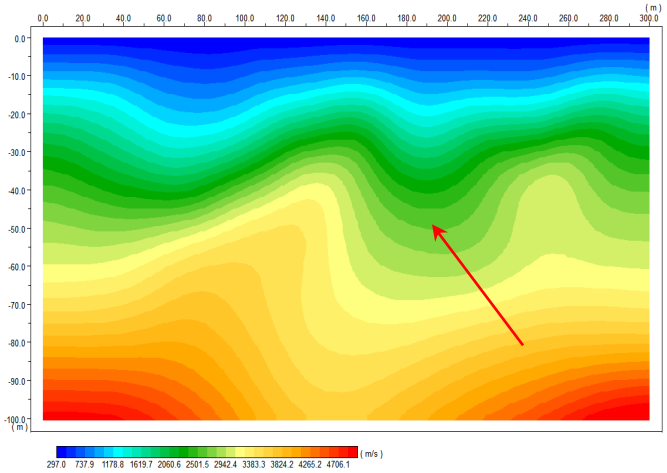
51shots

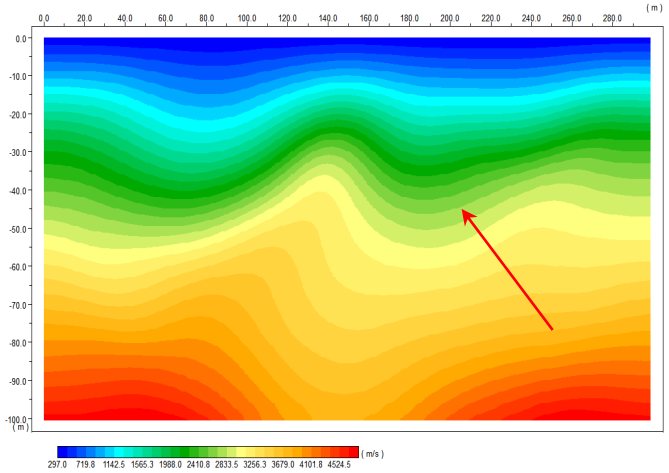
Error:2.312ms

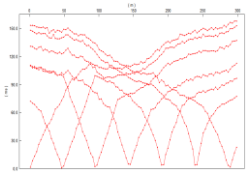


26shots

Error:3.081ms





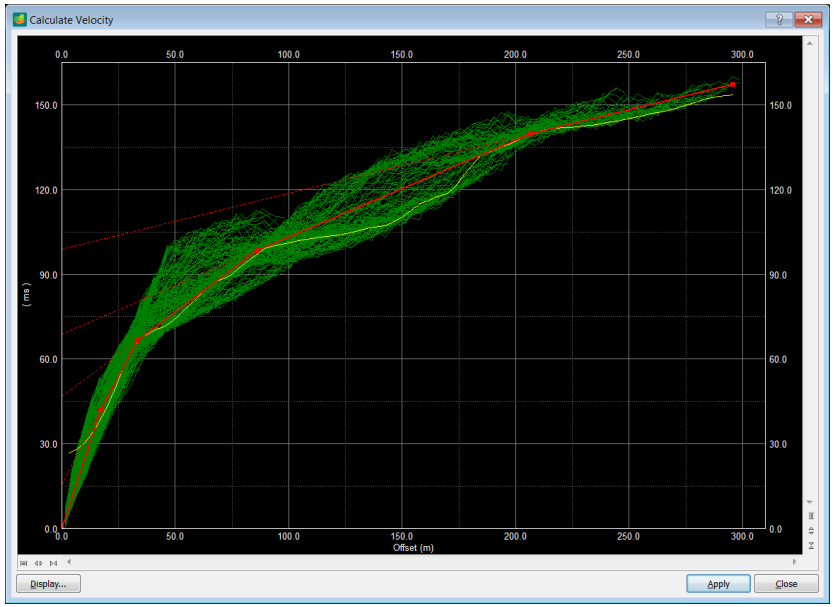


7shots

Error:3.301ms

GEOGIGA TECHNOLOGY CORP.

Comparison: Initial Model



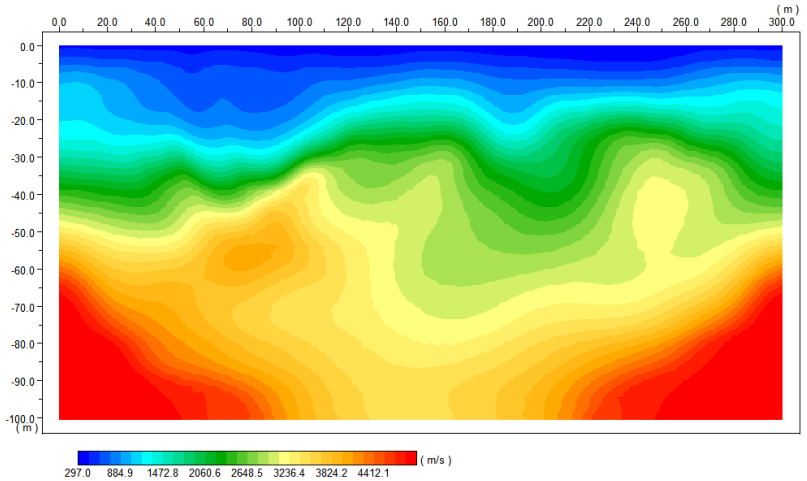
Time ~ Offset

Velocity Table

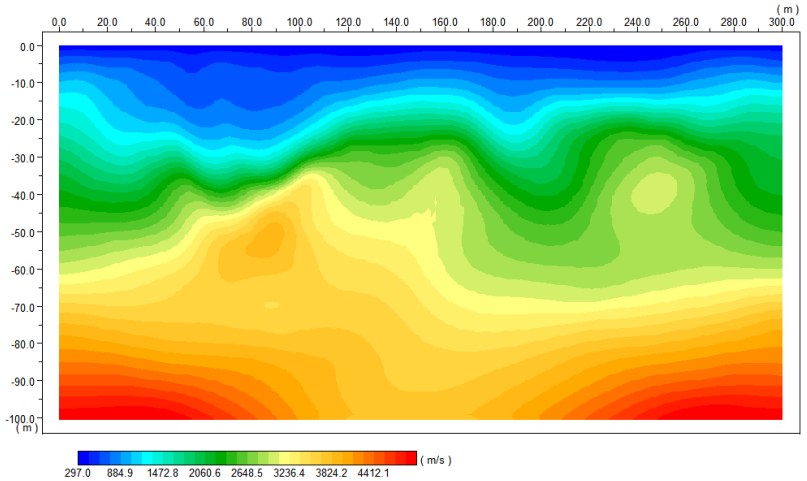
D(m)	V(m/s)
0.0,	400
4.0,	650
13.0,	1660
33.0,	2920
90.0,	5000

GEOGIGA TECHNOLOGY CORP.

Comparison: Initial Model(Cont'd)



D(m)	V(m/s)
0.0,	400
4.0,	650
13.0,	1660
33.0,	2920
90.0,	5000



D(m)	V(m/s)
0.0,	400
100.0,	5000

GEOGIGA TECHNOLOGY CORP.

Conclusion

- Graph method has advantages for seismic ray tracing
- Regularized approach provides lots of constraints to stabilize inversion
- Due to non-uniqueness of tomography, results change with parameters, but most of them are comparable