Rayleigh Inversion Application Study in Some Areas of Middle East*

Fuhao Jiang[1]

Search and Discovery Article #42217 (2018)**
Posted May 28, 2018

*Adapted from oral presentation at GEO 2018 13th Middle East Geosciences Conference and Exhibition, Manama, Bahrain, March 5-8, 2018

[1]BGP, Zhuozhou, Hebei, China (jiangfuhao@bgp.com.cn)

Abstract

The near-surface structure is very complex in some areas of Middle East, where the investigation is relatively challenging. This article introduces the study of multi-channel Rayleigh wave inversion for near-surface structure in some areas of Middle East.

Dispersive curve improvement
● Increase Rayleigh wave SNR (Signal-to-Noise) Ratio): To improve the low frequency S/N ratio of Rayleigh wave, multi-shots within near-offset are stacked, and Rayleigh waves are stacked in-phase within the acceptable error, so that the low frequency power and S/N ratio of Rayleigh wave could be improved.
● Optimize trace-selection based on frequency dispersion analysis: Because the near-surface structures in the study areas change rapidly, the locations and quantity of seismic traces are determined through the detailed analyses.

Inversion result improvement
● Model building method optimization: Rayleigh surface wave inversion has several model building methods based on the relation between phase-velocity and the depth transmitted from wave-length. In order to optimize the model building methods, three methods are compared with their inversion results in the study. The method with fixed layer number and fixed layer thickness shows probable application.
● Model depth optimization processing: Three steps are adopted to optimize the model depth: (a.) use the maximum depth to build model and inverse; (b.) adopt the dominant depth to build model and inverse; (c.) refine the models of the un-appreciated dispersive curves

● Inversion results processing: The section with phase-velocity and depth display cannot show the near-surface structure favorably:, so one gridding processing is done with the inversion results to improve some unsatisfactory inversion results. At the same time, the inversion results can be transmitted into interval velocity.

Results

Through the analyses, aiming at Rayleigh surface shortage in seismic data, the solutions are applied and Rayleigh wave SNR is improved. The lowest frequency of dispersive curves is extended to (5-7)Hz from (8-10)Hz, and the detecting depth of Rayleigh wave is increased to (140-180)m from (100-120)m. Through the comparison, the building model method with fixed layer-number and fixed layer-thickness is the optimum. At the same time, in order to improve Rayleigh wave inversion precision, some feasible solutions are applied, and good results are achieved.

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Fuhao Jiang

Mar. 6th, 2018

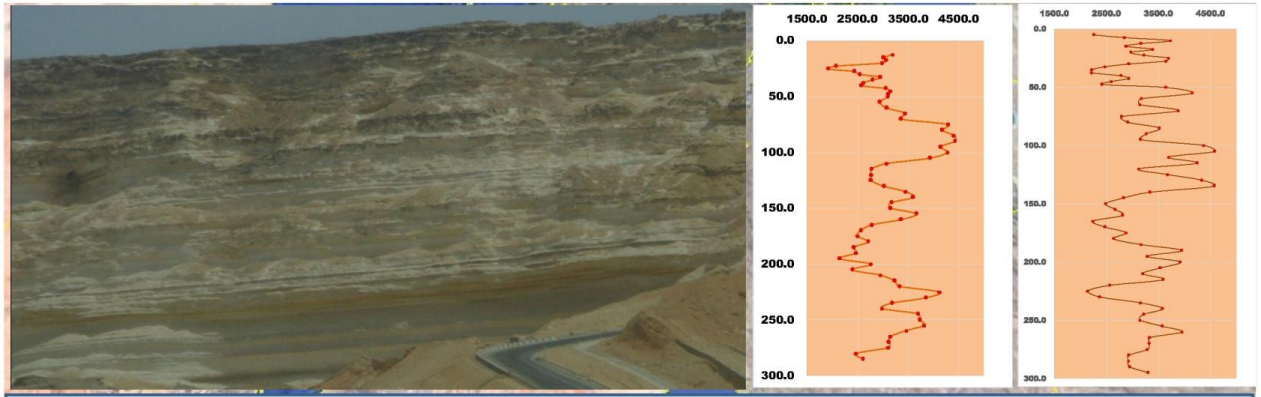
Content

1. Introduction
2. Challenges in MASW Analysis
3. Solutions for MASW Inversion
4. Results
5. Conclusions

Presenter's notes: MASW is acronym of Multi-Channel Analysis of Surface Waves.

1. Introduction

Complex near-surface structures bring some issues.



Data Processing Challenges

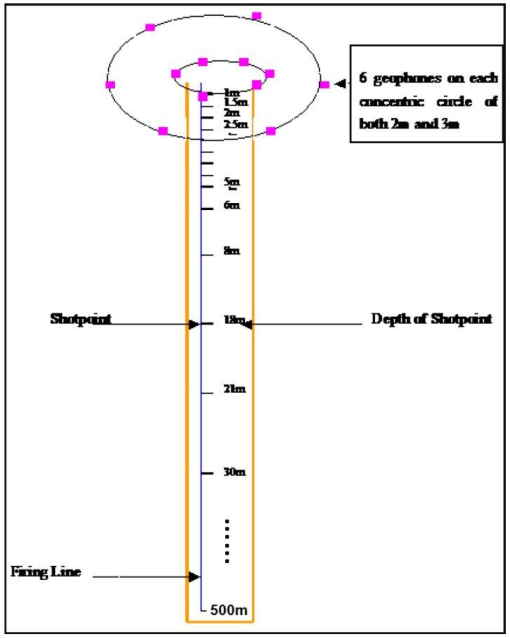
1. **Static correction**
2. **Interbed multiple pressing**

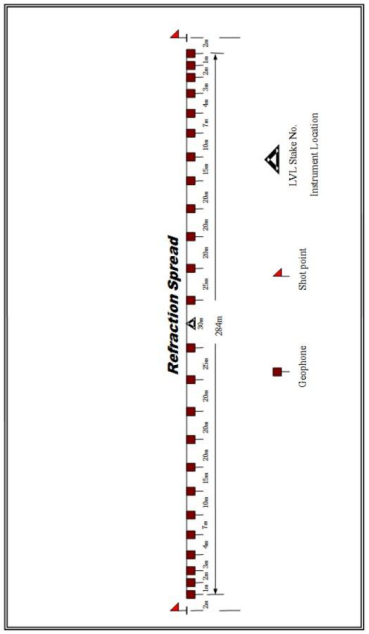
.....

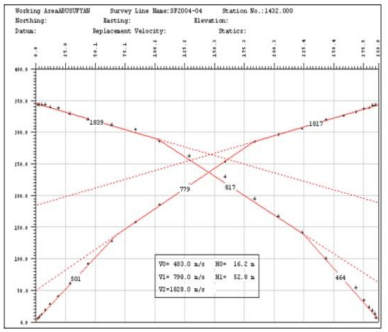
Presenter's notes: In some areas of Middle East, the near-surface structure looks very complex. Besides the weathered rocks on surface, the subsurface layers are interbedded, and that makes the seismic sections complicated. So it is necessary to study near-surface structure and recover the true section appearance for data processing.

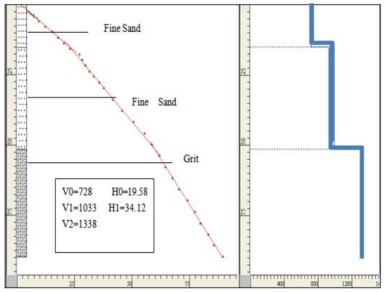
1. Introduction

Conventional near-surface investigation method challenges







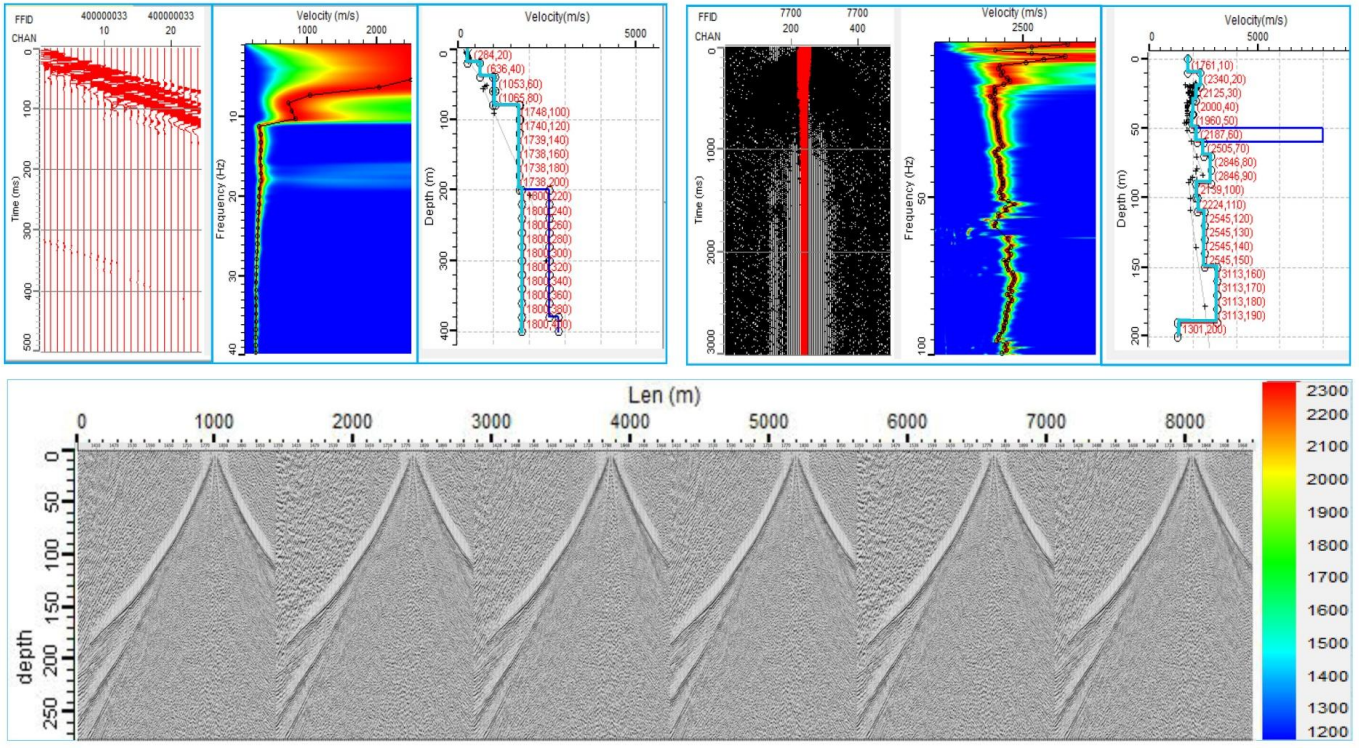


Deep, Expensive **V1<V2<V3<.....Vn-1<Vn n=1,2,3.....n Impossible**

Presenter's notes: Conventionally, uphole and LVL (Low Velocity Layer) are the main near-surface investigation methods. However, in the work area, uphole logging is luxury, and for LVL method, the interbedding makes it impossible for actual use. What should we do ?

1. Introduction

MASW inversion method highlights



Presenter's notes: According to the analysis, surface wave inversion method seems to be a good choice because the interbedding issue can be ignored, as the surface wave on true shot data is used to inverse near-surface structure; this is very economical. In our study, we adopt MASW method to perform frequency dispersion analysis.

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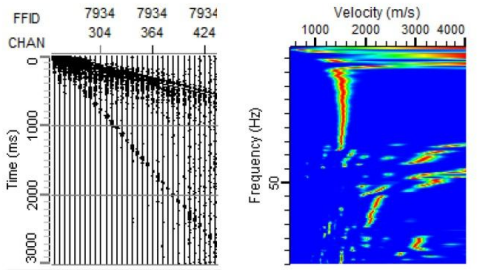
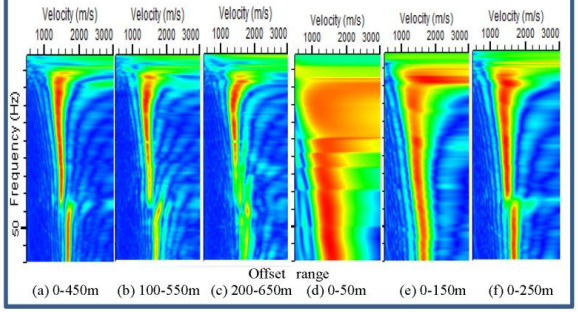
2. Challenges in MASW Analysis

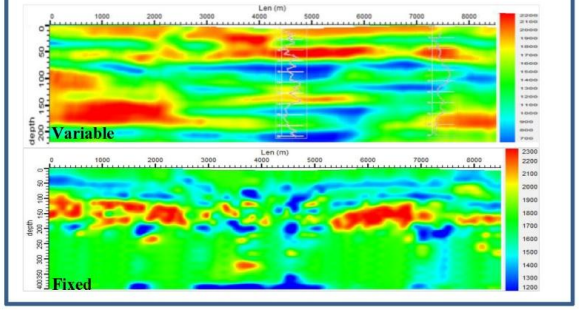
(1) Low surface wave S/N ratio



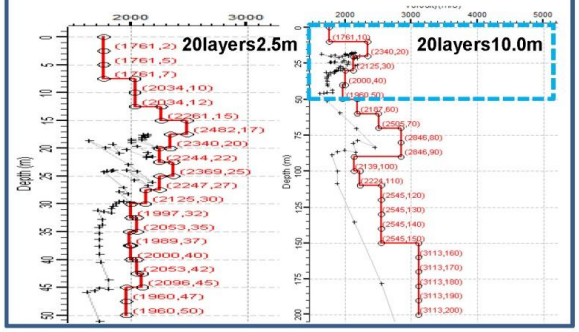
(2) Difficult determination of offset & trace number



(3) Fixed or variable layer thickness?



(4) Layer thickness and inversion depth



Presenter's notes: During the study, there are 4 types of challenges. The first is how to guarantee the lowest effective surface wave frequency; it controls the maximum inversion depth. The second is how to determine the traces for frequency dispersion analysis; different number of traces, different frequency, and dispersion accuracy; that will influence the inversion result. The third is determining if the LVT is variable or fixed. The forerm is determining layer thickness and inversion depth.

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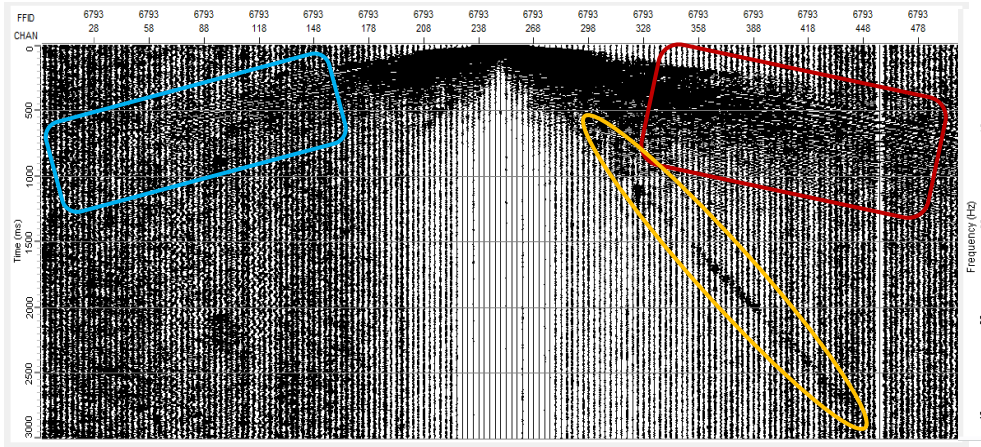
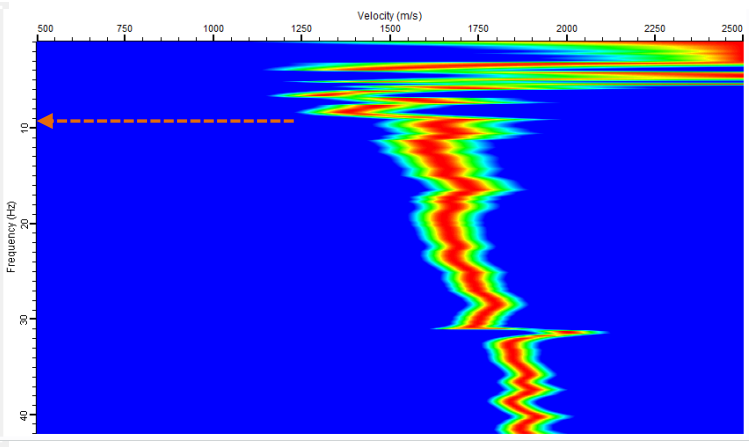
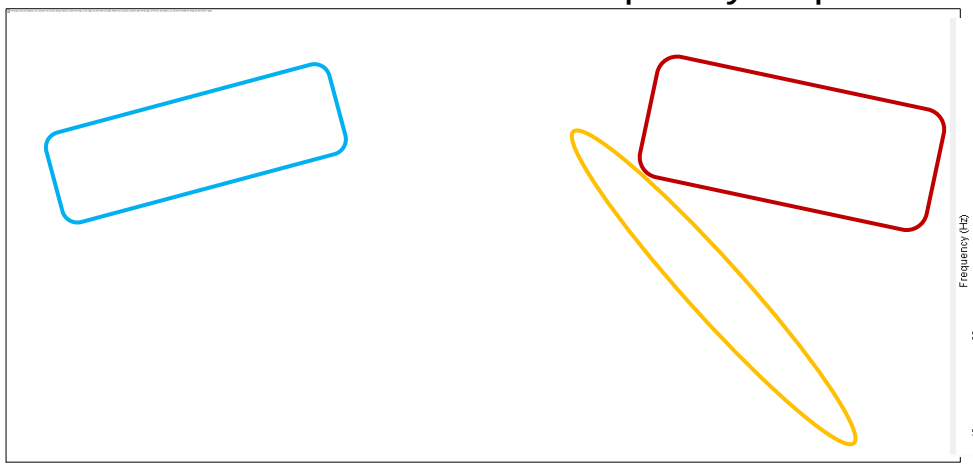
3. Solutions for MASW Inversion

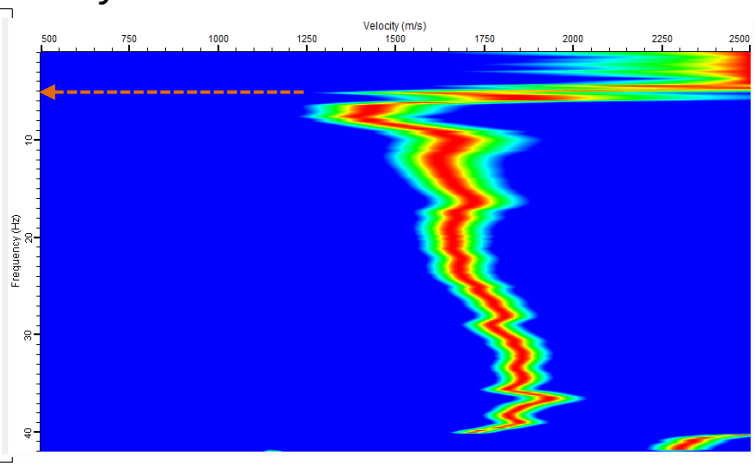
(1) Improve surface wave S/N ratio • **Adjacent shots vertical stack**





Shot data frequency dispersion analysis **before** vertical stack

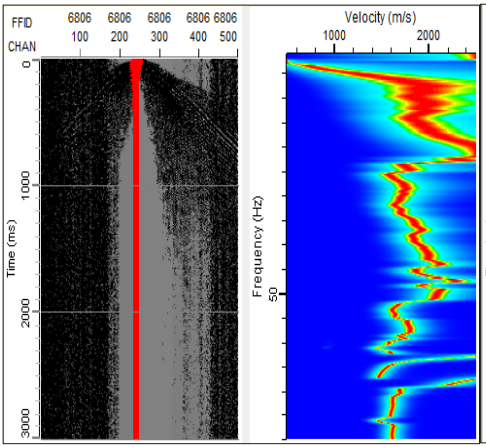




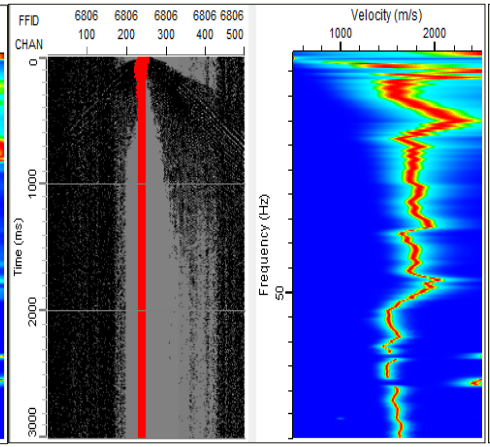
Shot data frequency dispersion analysis **after** vertical stack

3. Solutions for MASW Inversion

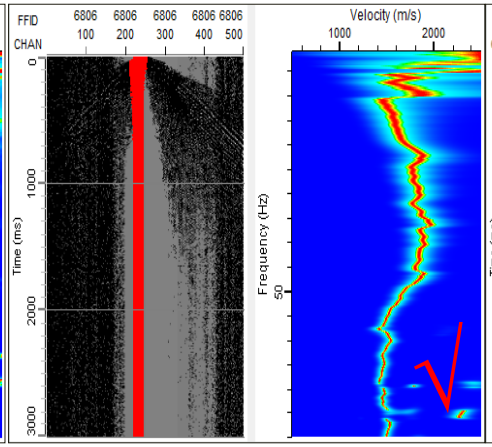
(2) Elaborate trace selection for frequency dispersion analysis



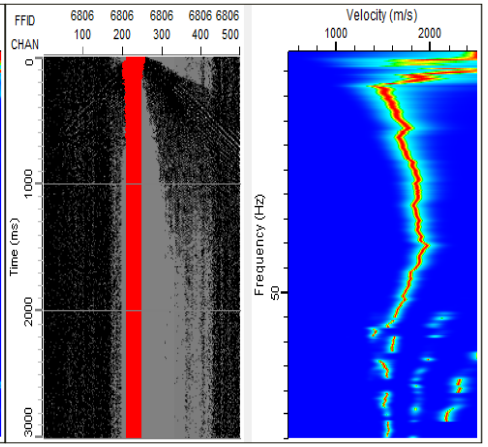
Trace 246-235



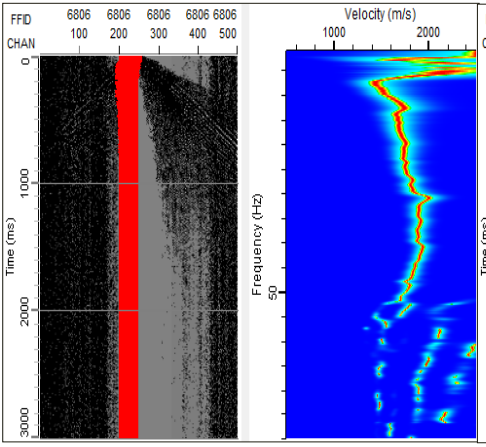
Trace 246-231



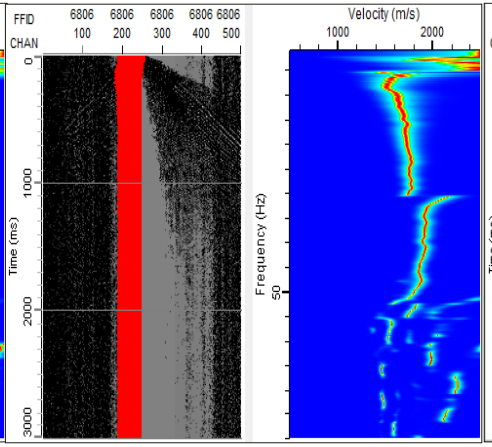
Trace 246-220



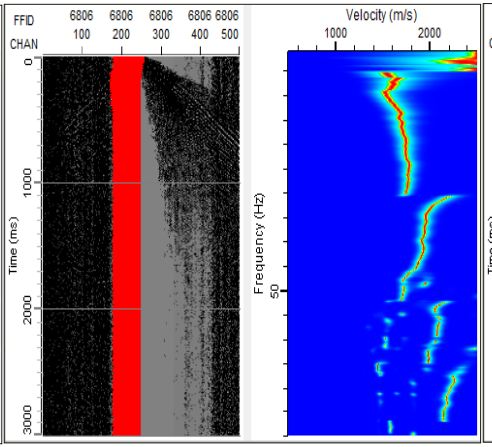
Trace 246-211



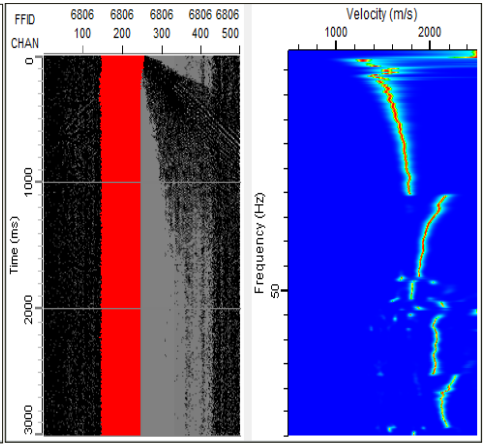
Trace 246-200



Trace 246-190



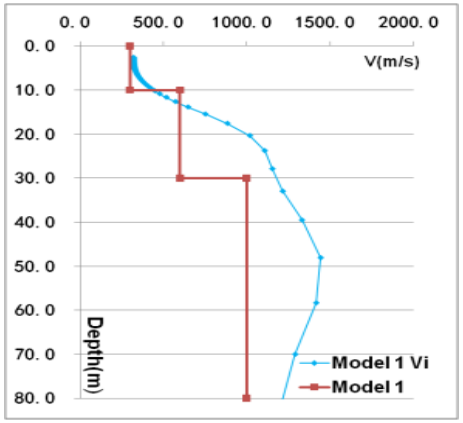
Trace 246-180



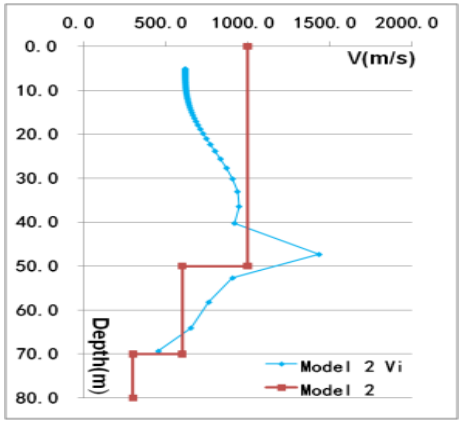
Trace 246-150

3. Solutions for MASW Inversion

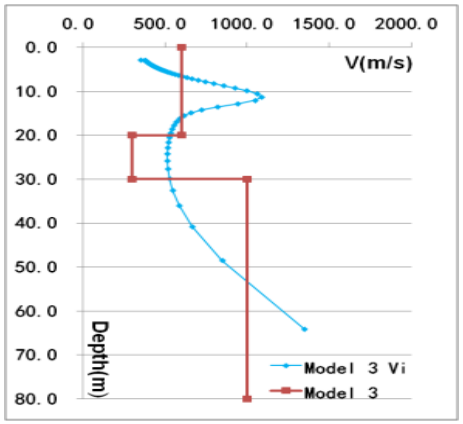
(3) Optimization of model building method



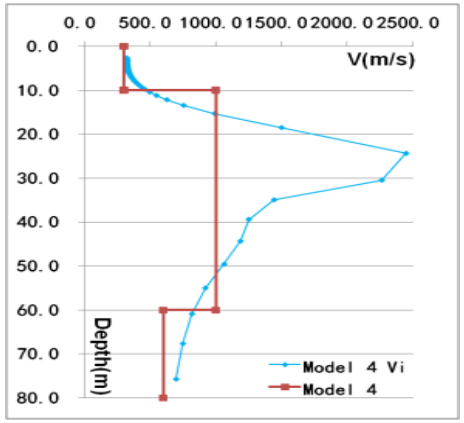
(a) True model 1 (red) & Inversion Model (blue)



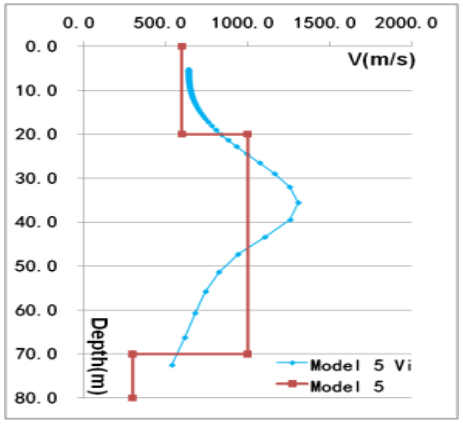
(b) True model 2 (red) & Inversion Model (blue)



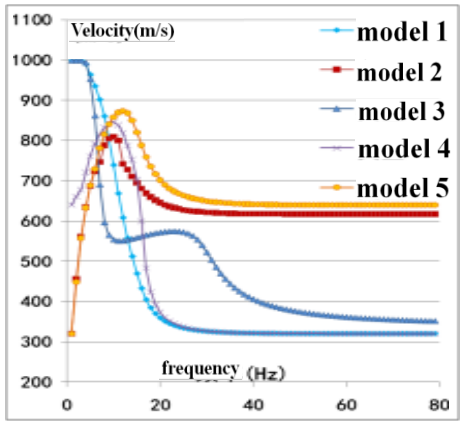
(c) True model 2 (red) & Inversion Model (blue)



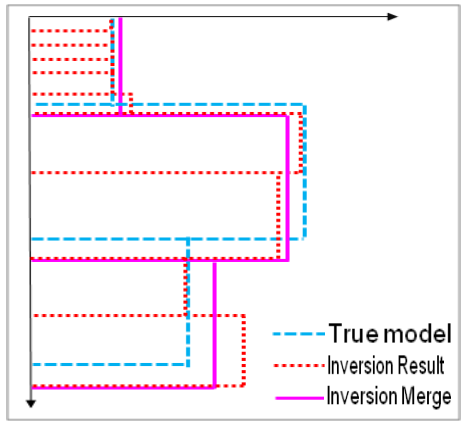
(d) True model 2 (red) & Inversion Model (blue)



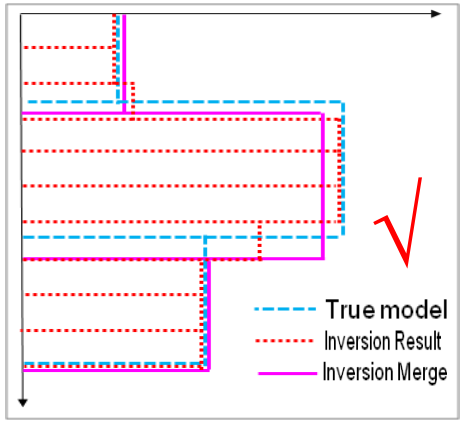
(e) True model 2 (red) & Inversion Model (blue)



Theoretical frequency dispersion curves



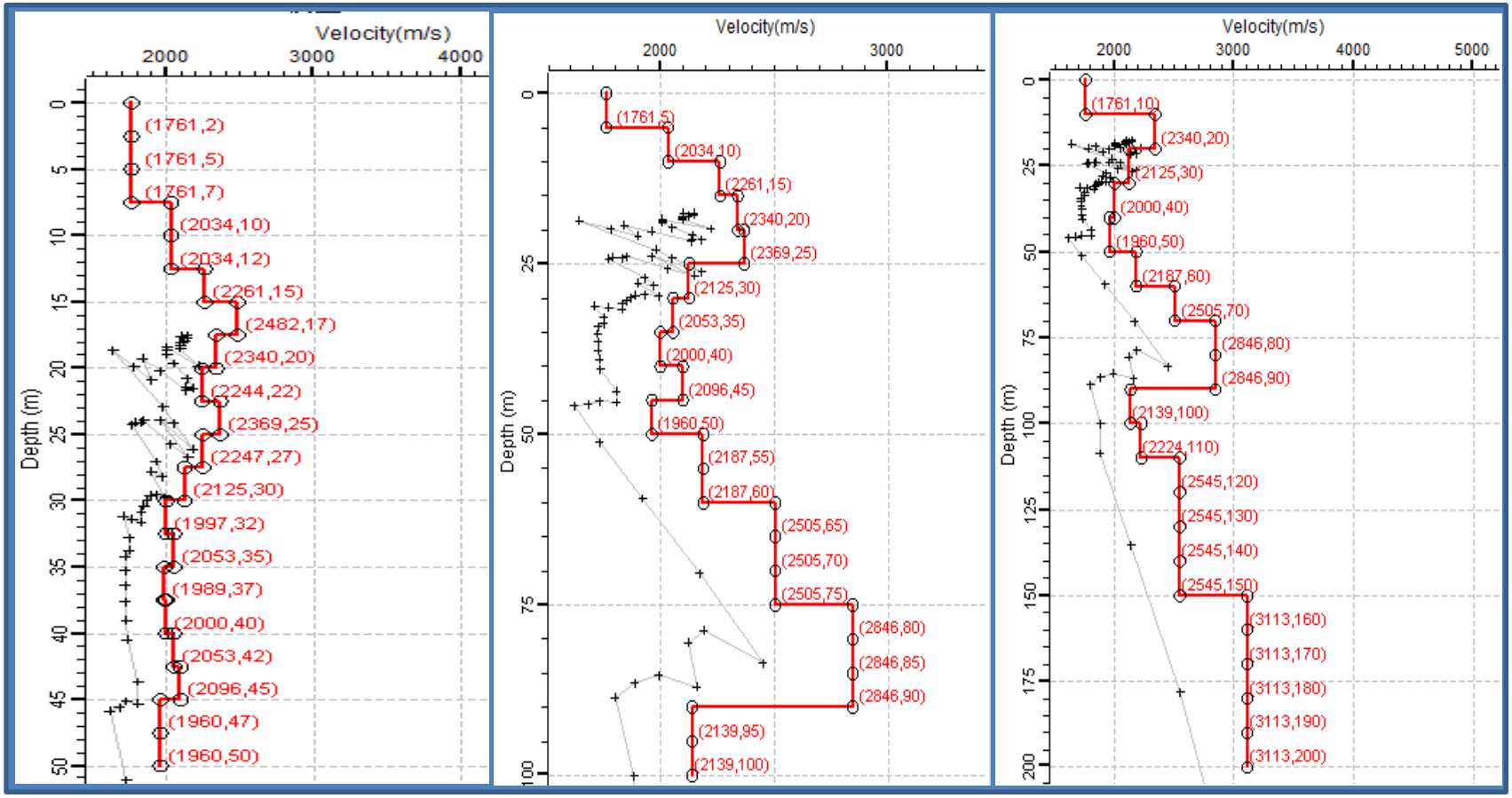
Unequal thickness model building chart



Equal thickness model building chart

3. Solutions for MASW Inversion

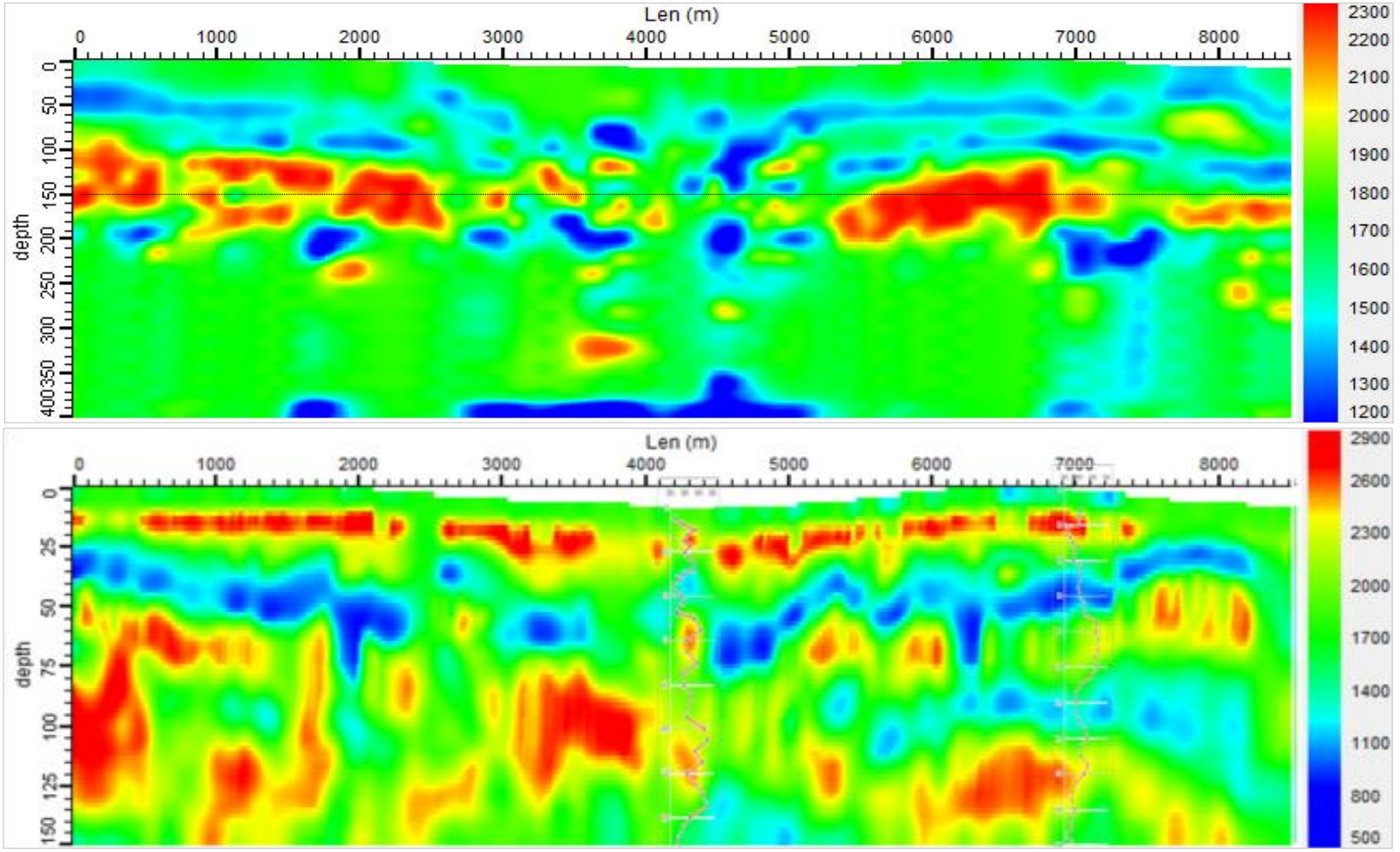
(4) Inversion layer thickness combined with inversion depth



Model layer thickness: 3m **Model layer thickness: 5m** **Model layer thickness: 10m**

3. Solutions for MASW Inversion

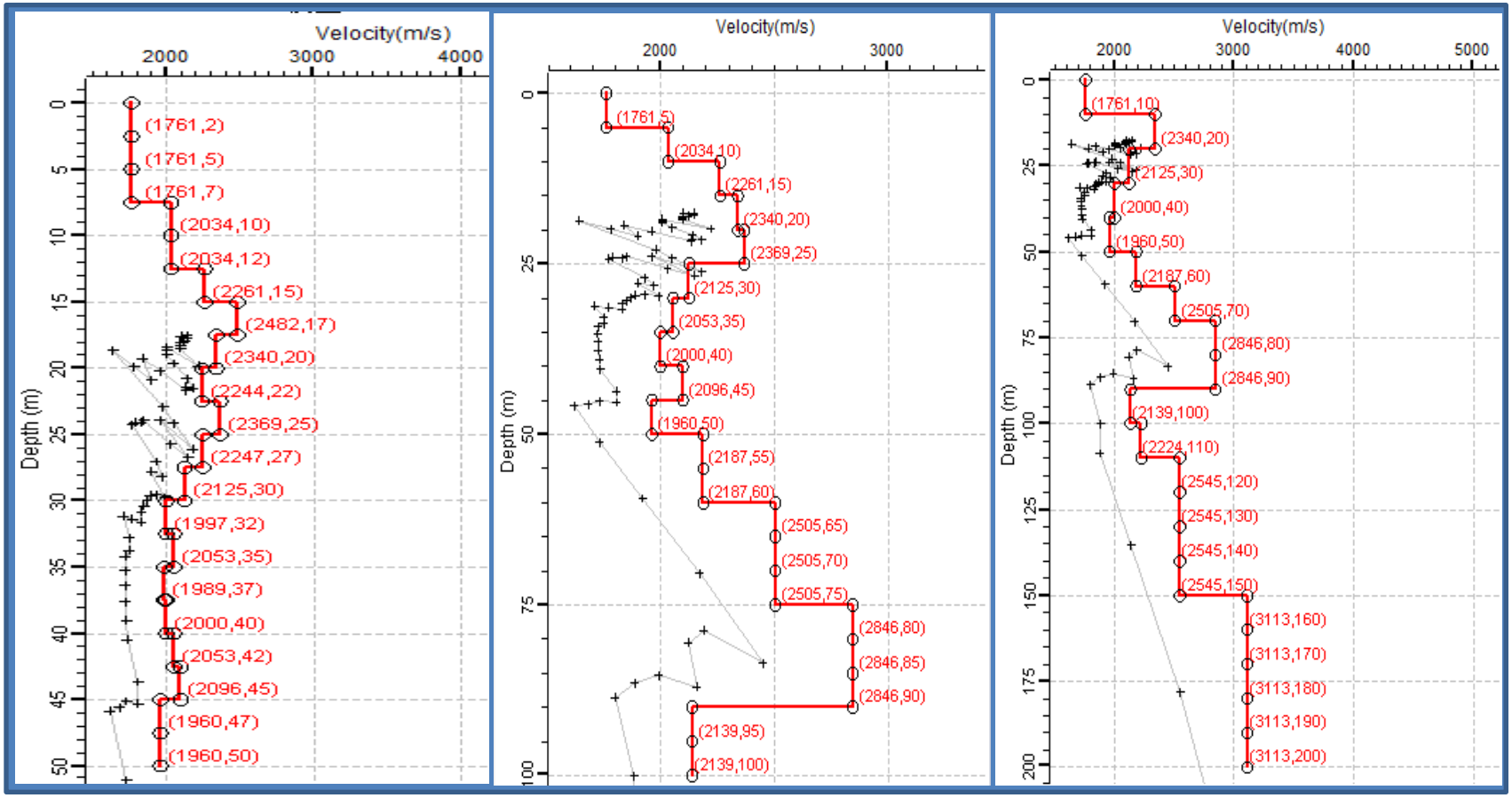
(4) Inversion layer thickness combined with inversion depth



Upper: big inversion grid size **Bottom: small inversion grid size**

3. Solutions for MASW Inversion

(4) Inversion layer thickness combined with inversion depth



Model layer thickness: 3m + **Model layer thickness: 5m** + **Model layer thickness: 10m**

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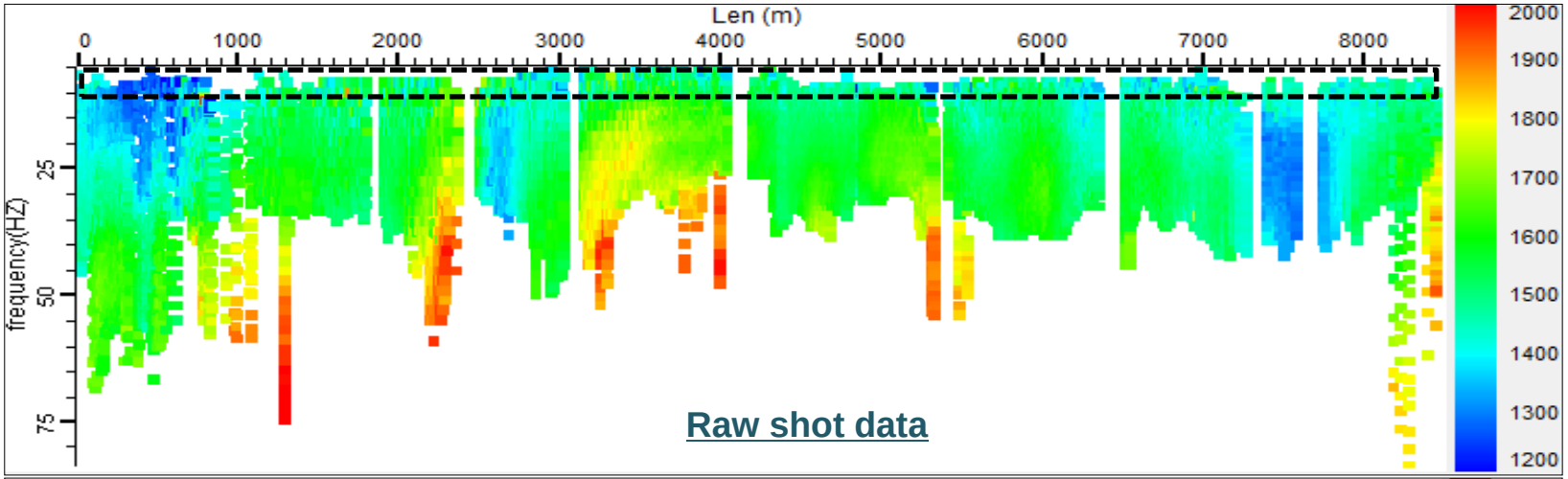
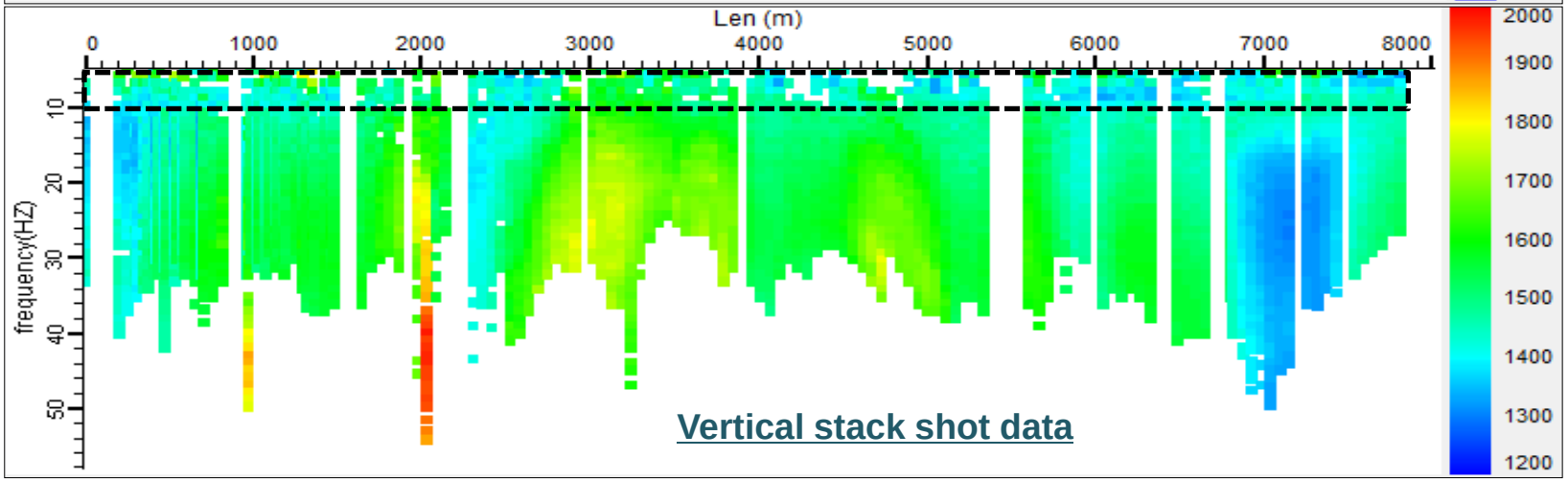
4. Results

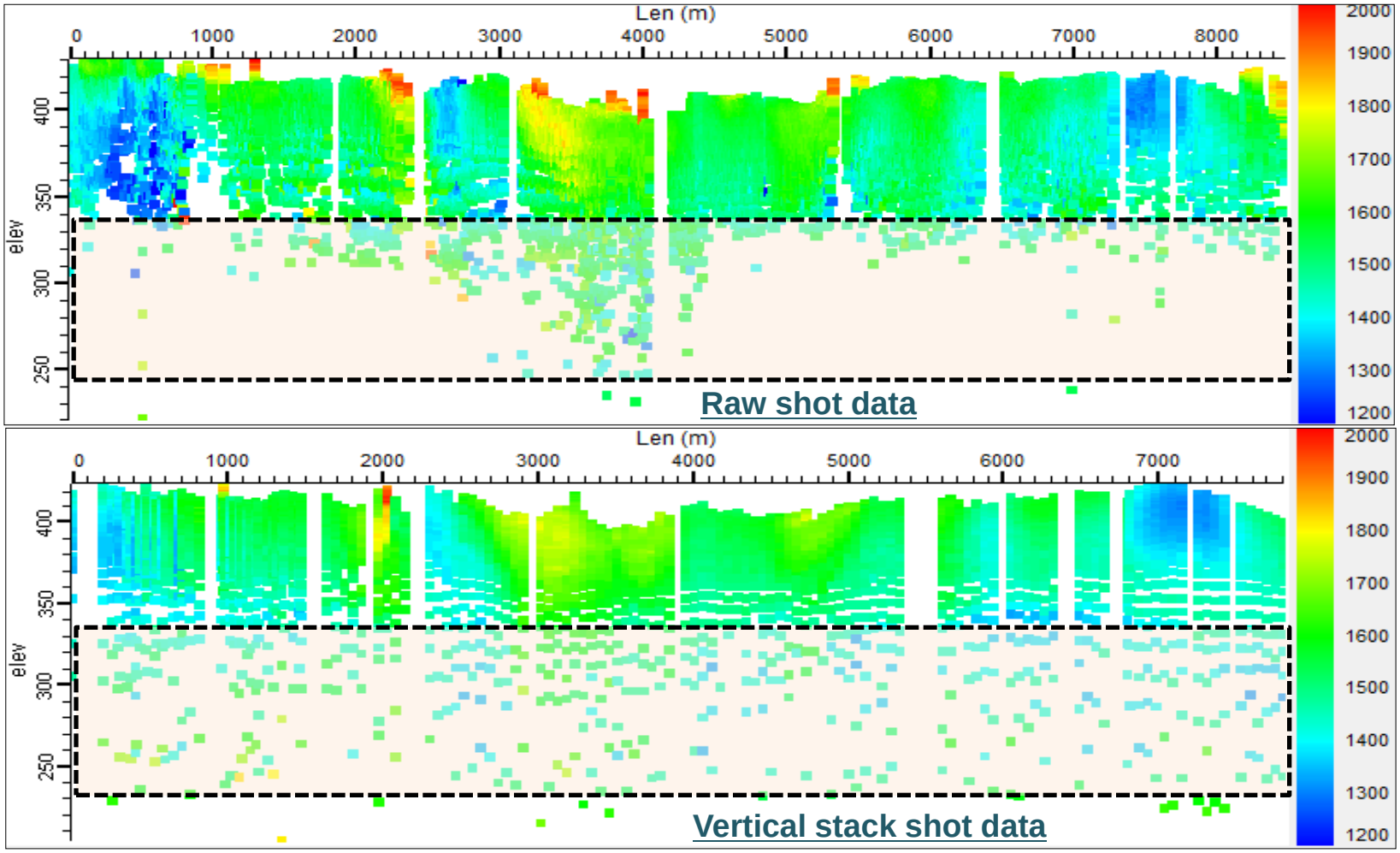
(1) Line frequency dispersion curve section Low frequency guarantee





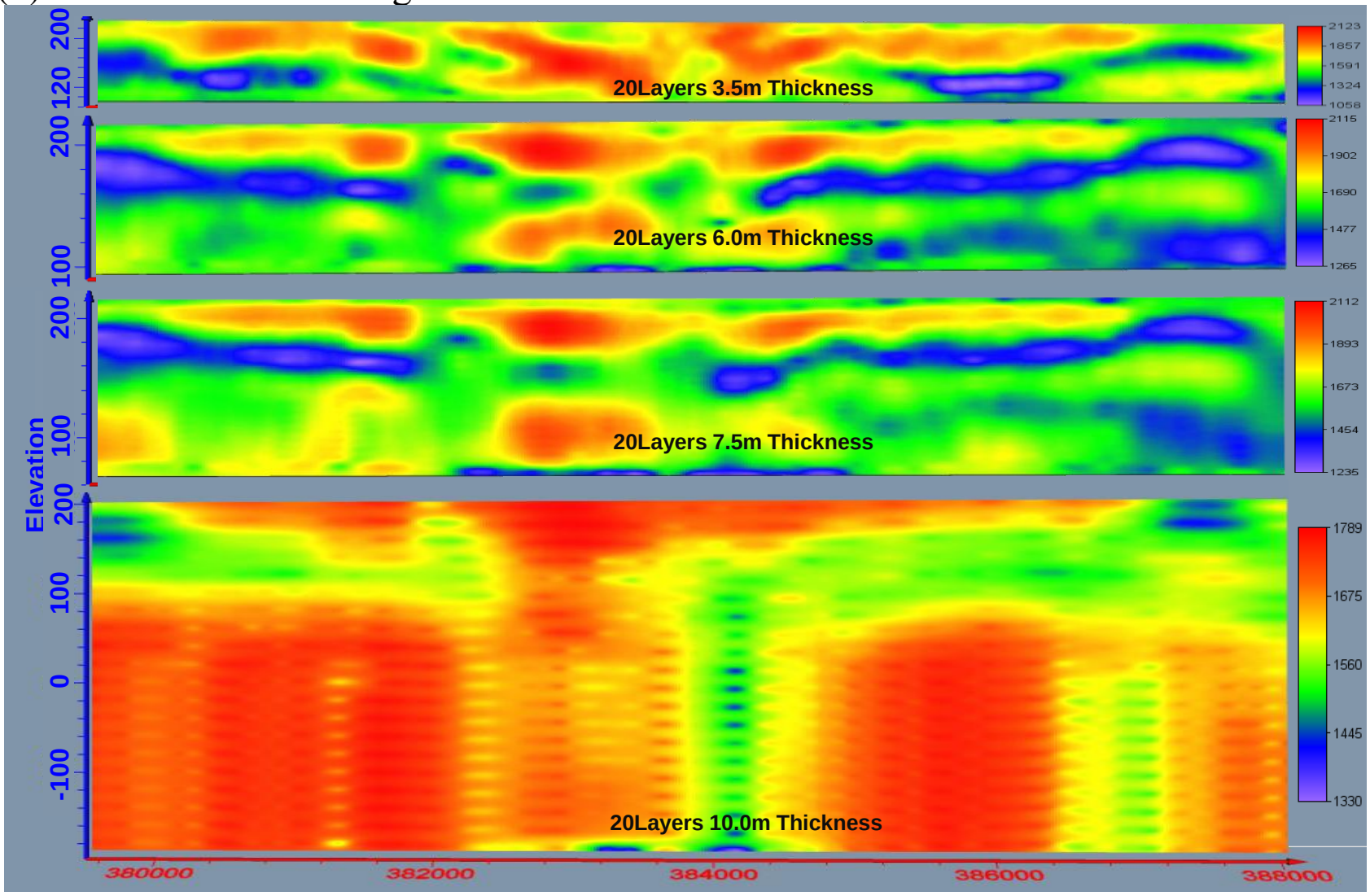
4. Results

(2) Near-surface section gained through half-wave length method



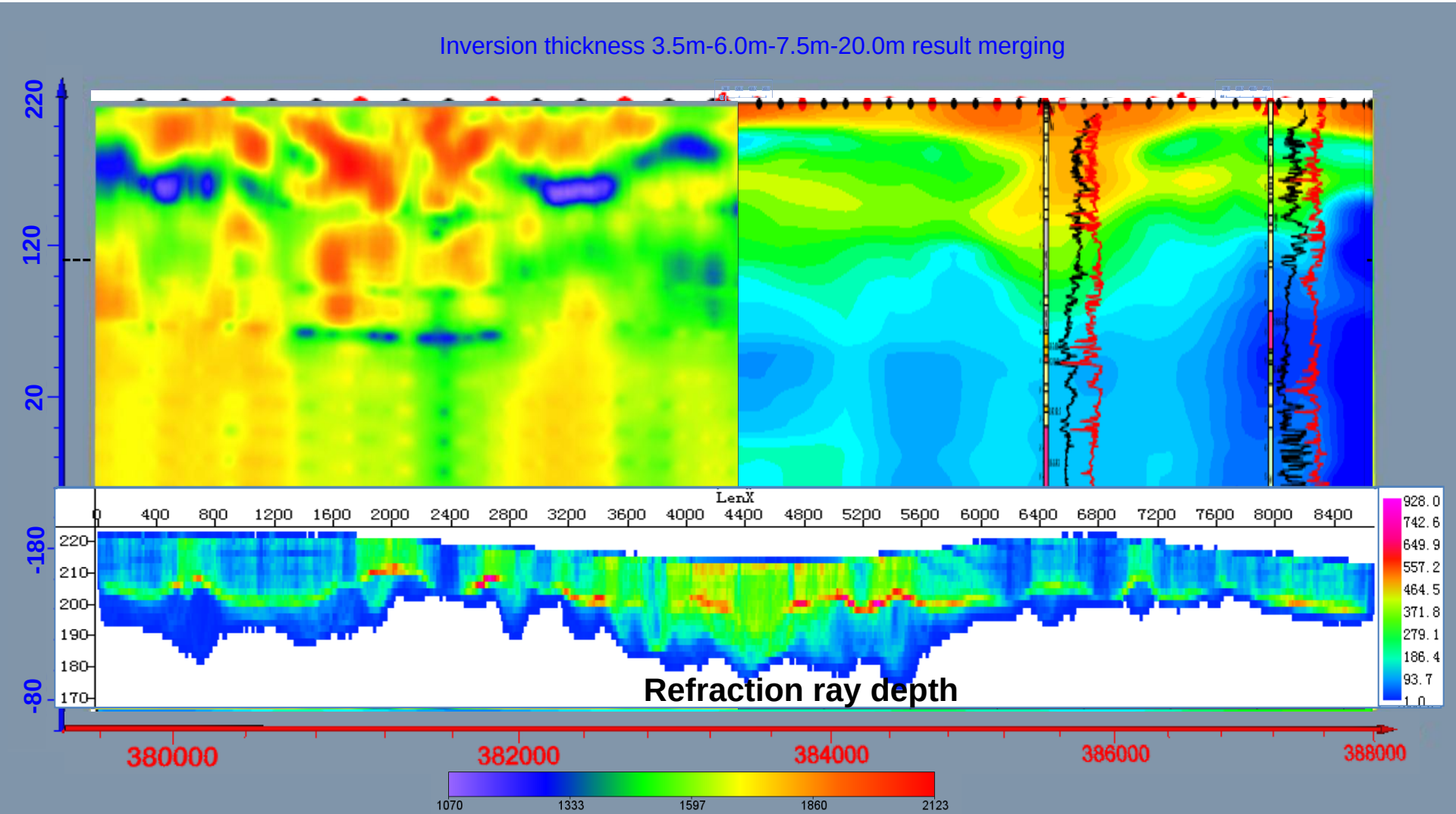
4. Results

(3) Near-surface section gained from MASW inversion with 2D shot data



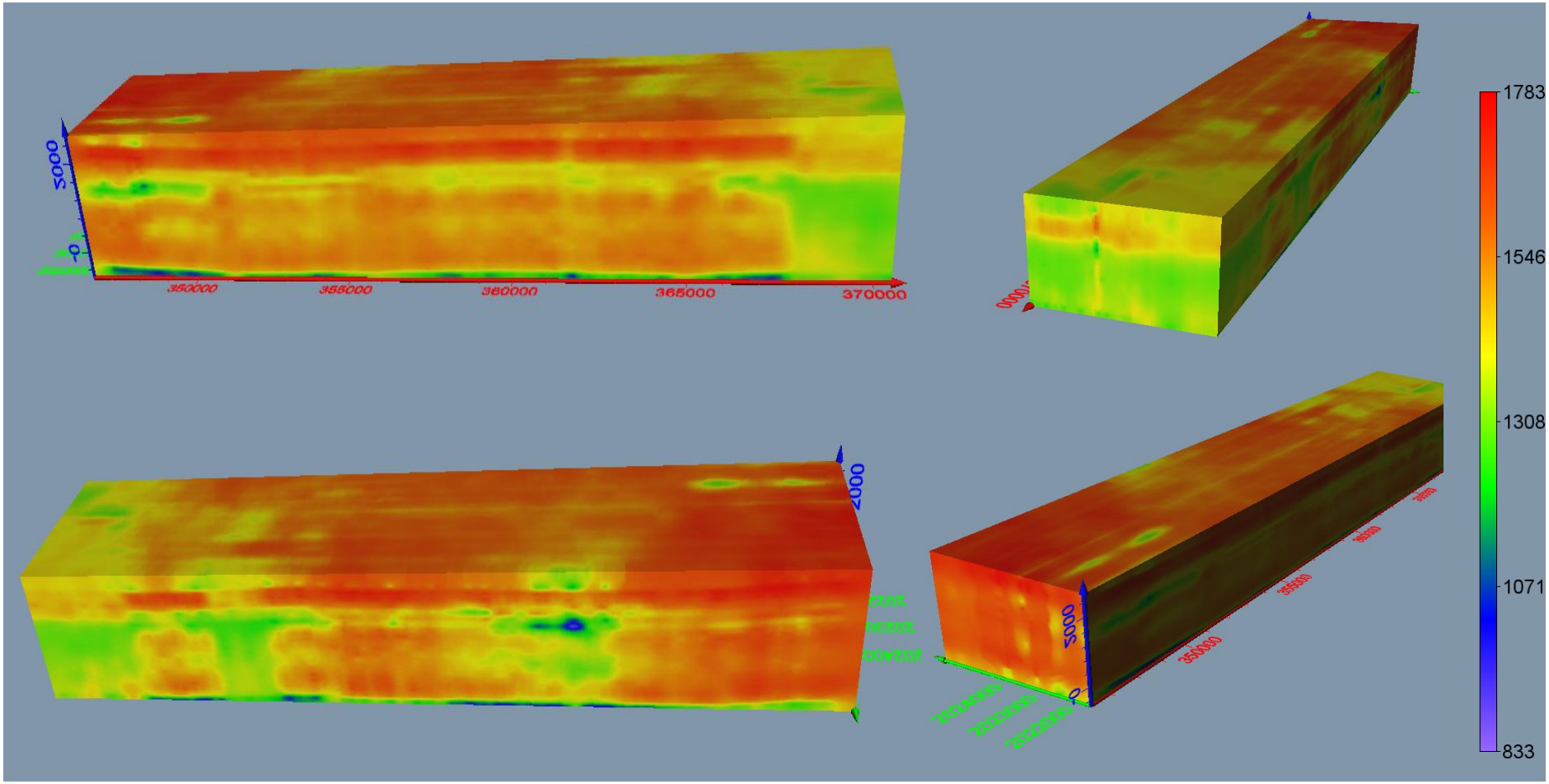
4. Results

(3) Near-surface section gained from MASW inversion with 2D shot data



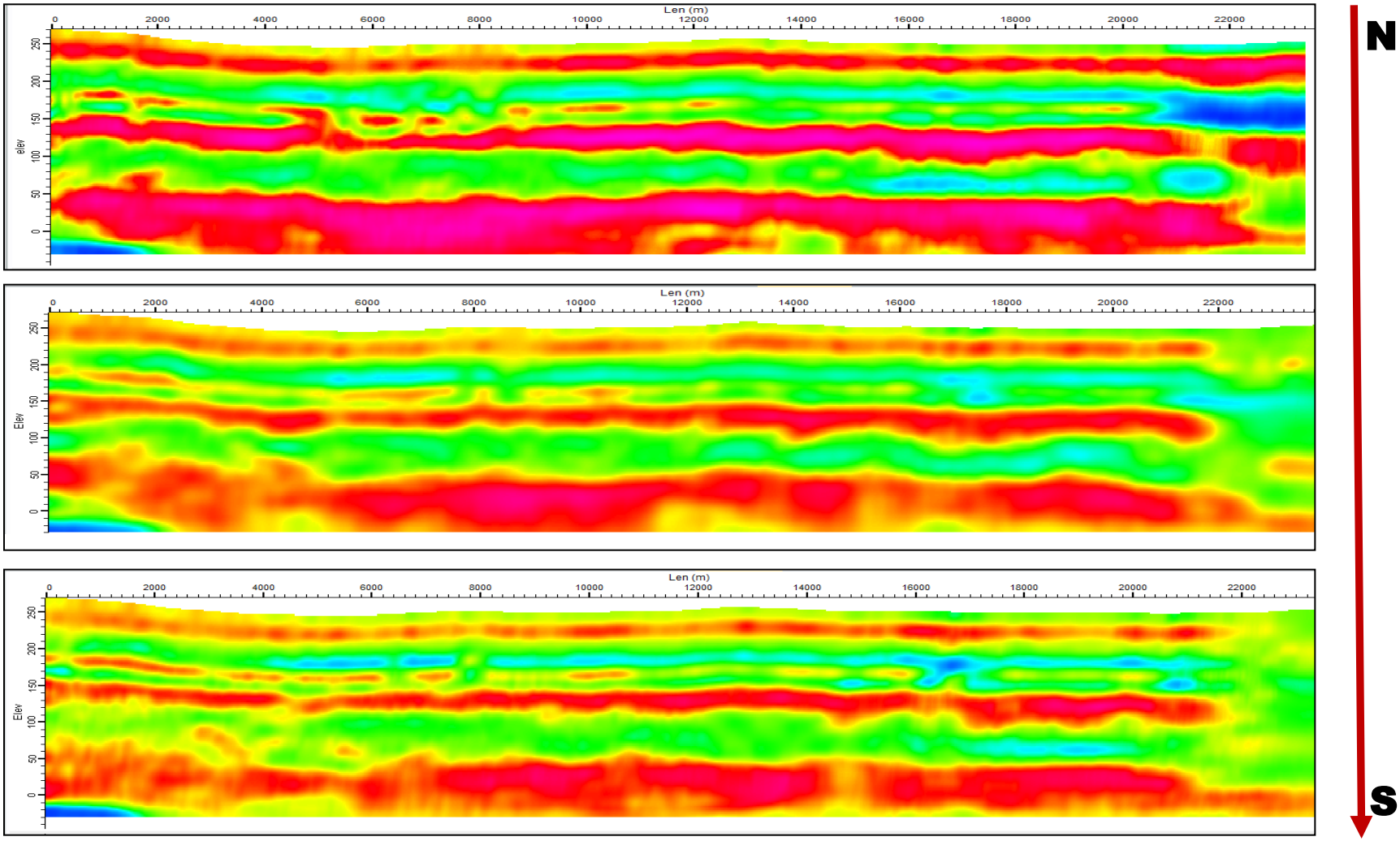
4. Results

(3) Near-surface section gained from MASW inversion with 3D shot data



4. Results

(3) Near-surface section gained from MASW inversion with 3D shot data



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5. Conclusions

(1) MASW inversion method is proved to be a possible solution for near-surface structure investigation with true shot data in Middle East area.

(2) Targeted processing, including de-noising, surface-wave energy enhancement, trace selection, etc., is helpful for near-surface structure inversion with true shot data .

(3) There is still some work under way for further and popular MASW application in Middle East area.

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Many Thanks for your attention !