

**Class 2: Land and Shallow Marine Near-Surface Problems**  
**Mon, Sept 14, 2009**

- Near-surface problems in Mideast, presentation by Dr. Tim Keho
  - Rugged topography, large velocity variations, and hidden layers
  - Review of near-surface imaging technologies and case histories
  - Discussion of potential research projects for this class
- 1) This class will start with the presentation by Dr. Tim Keho who is the team leader of the near-surface group at Saudi Aramco through the Internet videoconference. Dr. Keho has offered two papers to the students in this class.
  - 2) After the presentation, we shall review the near-surface complexity and seismic wave propagation in these areas. At this stage, we shall also review what we went through in the first class.
  - 3) For different types of near-surface structures, we shall discuss what imaging techniques should be applied.
  - 4) This is the hot part: I shall propose and describe several potential research projects that students may choose for this class. Students may come to front and propose other projects, and let's discuss if they are feasible.

**Near-Surface Imaging Techniques:**

- 1) Delay-time inversion (software available)
- 2) Generalized Linear Inversion with layer model
- 3) Refraction Traveltime Migration (software available)
- 4) Refraction Interferometric Migration (software available)
- 5) First-arrival traveltome tomography (software available)
- 6) Full-waveform tomography (software available)
- 7) Surface-wave dispersion-curve inversion (software available)

**Rugged Topography:**

Causing elevation statics, and breakdown of some imaging techniques

- Conventional refraction interpretation may fail
- Delay-time solution may fail
- Traveltime tomography is ok
- Waveform tomography: be careful about the free-surface implementation
- Surface-wave inversion may fail

## Large Velocity Variations:

- Eikonal wavefront raytracing may fail (square root of 2)
- Large vertical velocity variations – Delay-time may perform better
  - Surface-wave inversion may perform better
- Large lateral velocity variations – Traveltime tomography may perform better
- Waveform tomography should be ok, however, CFL condition (FD) may slow down the forward modeling speed

## Hidden Layers:

- All refraction methods fail
- First-arrival traveltome tomography may be ok in some cases
- Surface-wave dispersion-curve inversion should be ok
- Waveform tomography should be ok

## Potential Research Projects

- 1) **Comparison:** comparison of delay-time solution, traveltome tomography, and waveform tomography for processing 2D synthetics and real datasets. A real dataset with about 200 shots is provided for the work. Address the advantages and disadvantages of each technique by comparison.

No coding needed. For synthetic test, use TomoPlus software to design numerical models and then use TomoPlus to image.

### Difficulty: low

- 2) **Refraction Interferometry:** Imaging Moho with refraction interferometry. The conventional method for imaging Moho with long-offset refraction data is to invert refraction traveltimes. With the interferometry approach introduced in this class, refraction wavefield can be converted to *reflection* (codes provided), and then migrated by the reflection imaging approach. This may produce a new look of the Moho interface.

There is no real data yet. If any student has real data, then try it. It requires long-offset seismic experiments. The class requires finishing synthetic tests only. That means: 1) design a crustal velocity model with TomoPlus; 2) generate wavefield through finite-difference modeling; 3) apply correlation calculation (interferometry) and convert refraction to reflection; 4) migrate the “reflections” with PSDM (ThrustLine software).

This project requires two software packages: TomoPlus and ThrustLine, and separate interferometry codes (available).

**Difficulty: medium**

- 3) **Regularized GLI2D:** Develop a 2D Generalized Linear Inversion Program for layer models using the first breaks, following the paper by Hampson and Russell. But we shall apply Tikhonov regularization for the inversion. That should improve the inversion performance.

Students need to code a raytracer following the paper. Inversion program will be provided to students. This will be an original research, worth publishing. Real data is available.

**Difficulty: High**

- 4) **2D Delay-Time with Topography:** Develop a 2D delay-time solution that can handle topography for one-layer models.

Delay-time solution is quick, and reliable for deriving layered near-surface velocity model with smooth topography.

We may come up a few ideas to compensate the topography effects so that the approach can be used to handle topography.

Synthetic and real data are available. 2D multiple-layer delay-time solutions are available in TomoPLus.

**Difficulty: Medium**

- 5) **2D Waveform Tomography Applications:** Long-offset land data from Yumen, China available, about 28 km 2D line, 211 shots, fixed receiver array.

Apply full-waveform tomography to image the subsurface and derive the interval velocity model. Previous analysis is through DIX conversion or velocity scan.

**Difficulty: Medium**

- 6) **P-wave Receiver Functions for VSP:** For a 2D walkaway VSP, we do have three component data. If we switch to common receiver gathers, assuming at the surface receiving P-wave from downhole sources, then we could apply P-wave receiver-function inversion to image the near-surface S-wave velocity structures.

3C walkaway VSP data is available, need the receiver-function package

**Difficulty: High**

- 7) **Microseismic Interferometry:** Given an event without knowing the location and initial time, try to image the location of the event. Use one trace to correlate all other traces and then migration, repeat the loop for all of the traces, and then stack.

First test synthetic data, correlation codes are available, migration PSDM is available in ThrustLine.

We may receive some real data

**Difficulty: Medium**

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