Class 1: Introduction to Seismic Wave Propagation
Wed, Sept 9, 2009

Today we are going to discuss about the following issues:

- Brief review of global Earth structures and seismology
- Near-surface geology and velocity structures
- Seismic wave propagation in the near-surface area
- Near-surface seismic statics corrections
- Review of seismic data processing workflow

Brief Review of Global Earth Velocity Structures and Seismology

Continental or Oceanic Crust – varies globally, Moho discontinuity
Mantle - upper-mantle discontinuities
- lower mantle, uniform and less variation
Most global seismic studies focus on the crustal and upper-mantle velocity structures.

Outer Core – liquid, iron-oxygen or iron-sulphur alloy, (V_s=0)
Inner Core – solid, iron, (V_p = 3.7 km/s)
Velocity range: P-wave: 5.0 km/s to 13.5 km/s
S-wave: 0.0 km/s to 7.0 km/s

Wave-propagation studies in the global scale:
Regional Pn –wave
Teleseismic P-wave and S-wave propagation
Surface-wave propagation at different scales

P-SV-Rayleigh-wave propagation plane
SH- Love-wave propagation plane

Technologies for imaging the Moho:
- Regional seismic modeling
- P- and S-wave receiver functions
- Surface-wave inversions
- Ambient noise interferometry

Technologies for imaging the upper mantle:
- P- and S-wave receiver functions
- Surface-wave inversions
- Multiple modeling at teleseismic distance

Near-Surface Geology and Velocity Structures

Topography variations, weathering layers over bedrock, overthrust, hidden layers, sink holes, and other anomalies …
P-wave velocity range: 340 m/s to 6500 m/s

P-wave source: near-surface seismic waves include direct P, reflections, refractions, diffractions, conversions, and surface waves.

Synthetic full wavefield finite-difference simulation shall be demonstrated for the following situations:

- Propagation in a simple one-layer over half a space model
- Propagation in a positive linear-gradient layer over half a space model
- Propagation in a hidden-layer velocity model

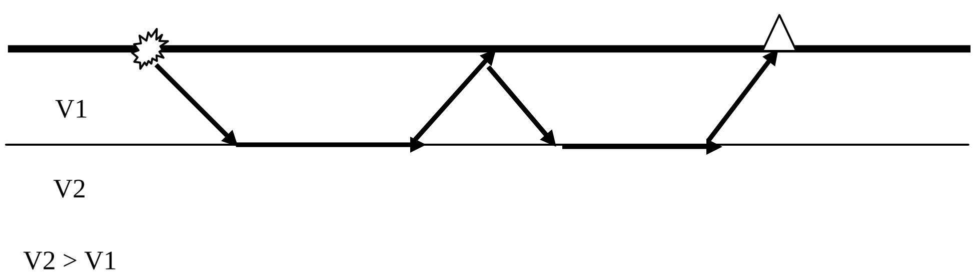
What did we learn from the above snapshot movie show?

Seismic technologies for imaging the near-surface areas include:

1) Refraction traveltime interpretation methods
2) Refraction delay-time solutions
3) First-arrival traveltime tomography
4) Early-arrival waveform tomography
5) Refraction traveltime and wavefield migration
6) Refraction wavefield interferometric migration
7) Near-surface dispersion-curve inversions

Question 1): Is it possible that the P-wave velocity in the near-surface area is less than 340 m/s (air velocity)?

Question 2): Is the following raypath diagram possible? Why?



The Concept of Near-Surface Statics Corrections

Assumptions behind statics corrections:

Vertical traveltime correction: good for deep reflections, bad for shallow reflections
Surface-consistent: at a particular position, there is only one single statics for reflected waves coming with different incident angles to the surface and from different azimuth. When does that fail? Who knows? Just try and then you will learn from the brute stack!

Intermediate (floating) datum: down-going traveltime calculation with the velocity model resolved from near-surface imaging, from original shot or receiver position down to the Intermediate Datum.

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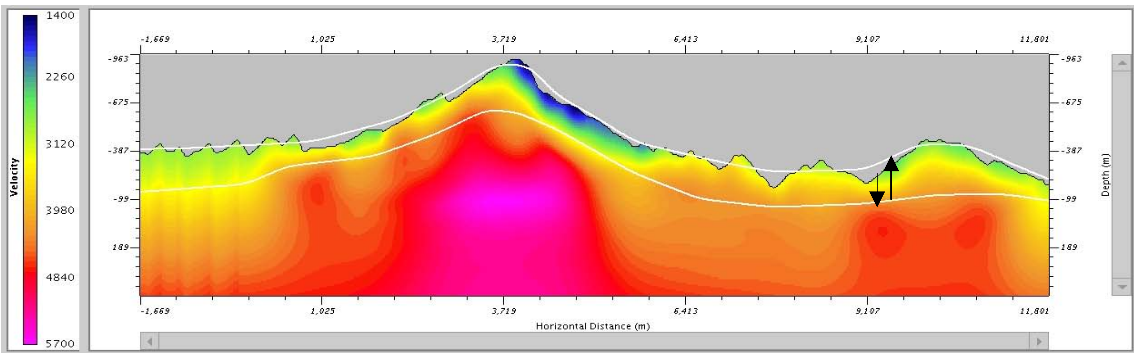
Final (floating) datum: up-going traveltime calculation with a constant replacement velocity from the Intermediate Datum to the Final Datum.

Note: "floating" is the term as opposed to "flat."

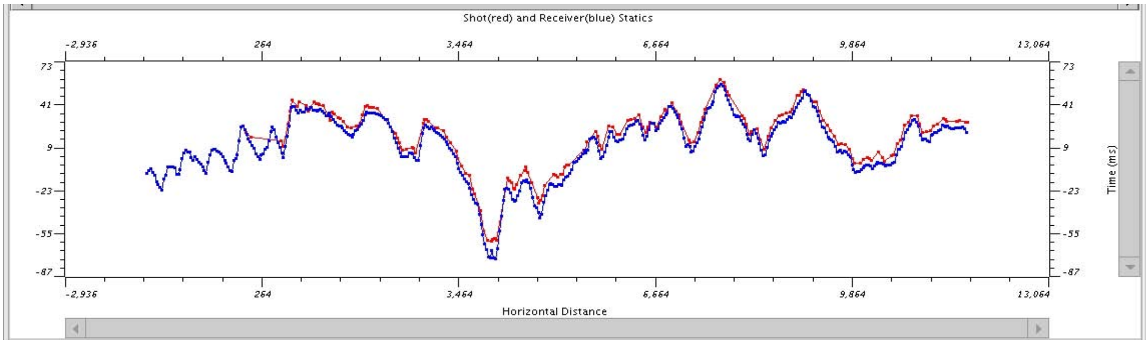
Replacement velocity: a constant velocity, usually the average of velocity below the intermediate datum.



Statics should include:

- long-wavelength statics associated with the near-surface velocity model
- short-wavelength statics resolvable from refraction traveltime analysis
- residual statics usually from reflection stack-power maximization
- trim statics, usually derived from differentials in event times based on processing experiences

Calculated long-wavelength statics (shot statics in red, receiver statics in blue) using the above model and intermediate and final datum defined:



Review of Land Seismic Data Processing Workflow

Conventional seismic data processing workflow:

- Geometry building and QC
- Near-surface <u>statics</u> solutions (*high-end research*)
- Signal processing – reduce noise and surface waves, apply <u>statics</u>
- CMP sorting, Velocity Analysis, NMO Correction, DMO Correction
- Stacking (zero-offset), migrate in time and depth

(Oz Yilmaz's workflow)

Prestack time- and depth-imaging workflow:

- Geometry building and QC
- Near-surface <u>statics</u> solutions (*high-end research*)
- Signal processing – reduce noise and surface waves, apply <u>statics</u>
- Picking RMS velocity fields (*high-end research*)
- Perform PSTM along with wavefield datuming
- Deriving the interval velocity model (*high-end research*)
- Perform PSDM