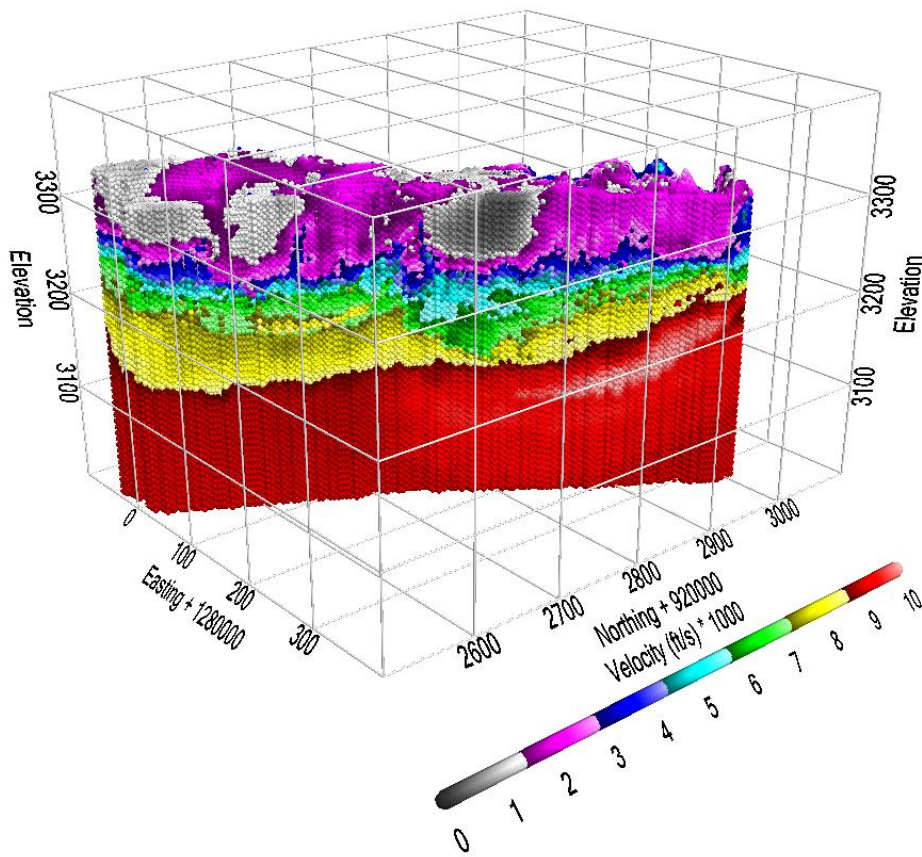

M3 REFRACTION TOMOGRAPHY ANALYSIS BLUE RIDGE

Publication

December 2005



U.S. Department
of Transportation
Federal Highway
Administration



EFLHD Blue Ridge 3D Refraction Tomogram Analysis Procedure

Refraction Tomography is a technique for producing 3D tomographic images from surface seismics. The seismic data can be collected from standard surface refraction shot-lines, or from sources and receivers at arbitrary locations on or below the surface.

M3, a DEM-PFC (discrete element particle flow) numerical model optimized for dynamic seismic applications, is used to process the seismic data. The waveforms are automatically analyzed to determine refracted arrivals. The material properties of the model are iteratively adjusted until the refracted arrivals in the model match the refracted arrivals collected in the field.

First, the arrivals were picked. The common-shot plot for source S-1 in Shot-line A is shown in Figure 1. Signals for the common-shot are shown beneath the corresponding receiver location. All signals are plotted and clipped at the same amplitude levels. Manual picks are shown in purple, and automated picks are shown in light blue. Zero picks indicate that the trace was not picked. The manual picks were used to train the automatic picker. The automatic picker discarded signals with low confidence picks. All arrival picks were cross-examined in both common-shot and common-receiver plots.

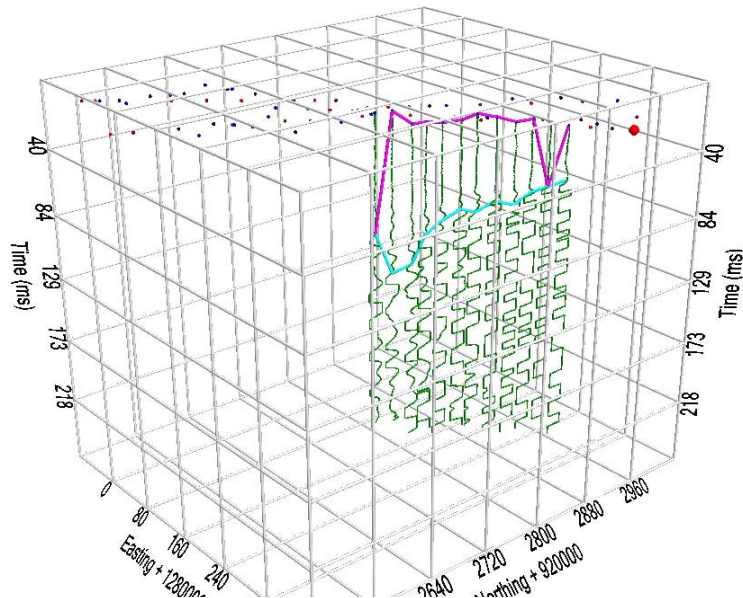


Figure 1. Common-shot for source S-1 from Line A Automatic arrival picks are shown in light blue. Manual picks are shown in purple. Zero Picks indicate that the trace was not picked.

The refraction tomogram was computed in 8 iterations starting from a homogenous velocity model. Two iterations were computed at 32, 16, 8, and 4 foot resolutions. This technique allows tomographic reconstruction at higher resolutions with reduced distortion. The resulting velocity model is shown in Figure 2.

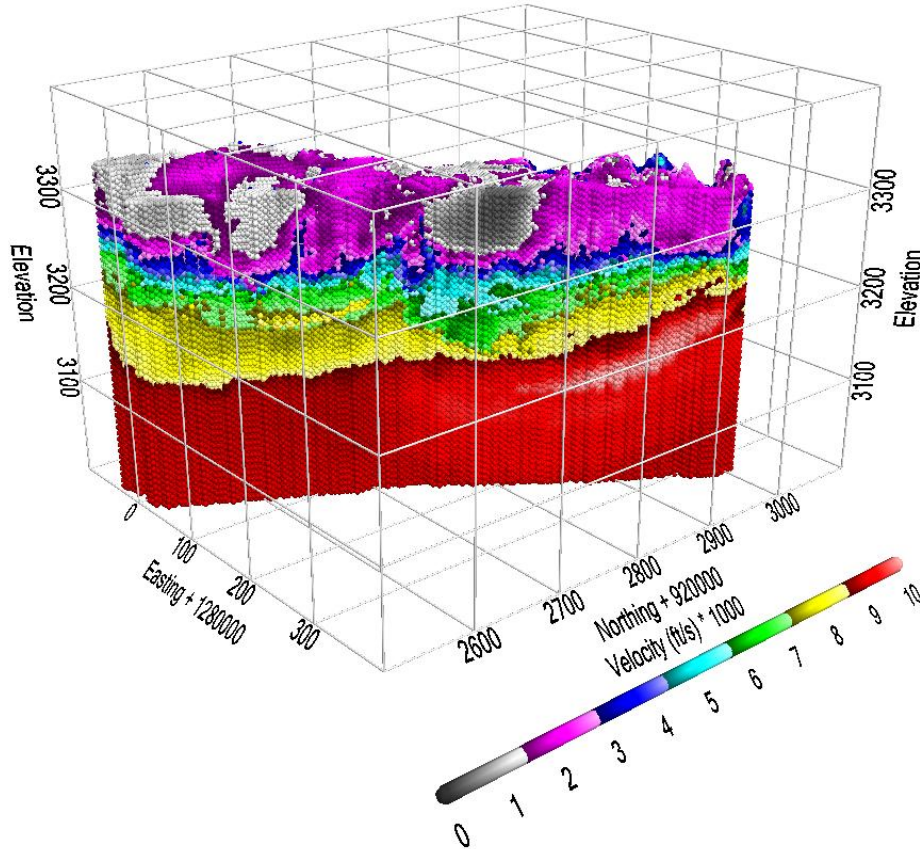


Figure 2. 3D Refraction Tomogram Velocity Model at 4 ft Resolution.

These velocities were then mapped to materials using boring logs, as shown in **Error! Reference source not found.**

Refraction Tomography allows reconstruction of both vertical and lateral velocity variations. A plot of the velocity variation within each layer is shown in **Error! Reference source not found.**

The ray-path coverage for all rays in the model is shown in Figure 5. A ray is a region in the model that has the highest contribution to the first arrival time, and typically descends from the surface source to higher velocity layers before ascending to the surface receiver. In this survey, the rays descended approximately 150 feet below the surface.

The top of the layer elevations beneath the receiver stations is shown in Table 1, including corresponding surface elevations and station coordinates.

PowerPoint presentation slides and animations showing various slices and perspective views are provided as an addendum to this report.

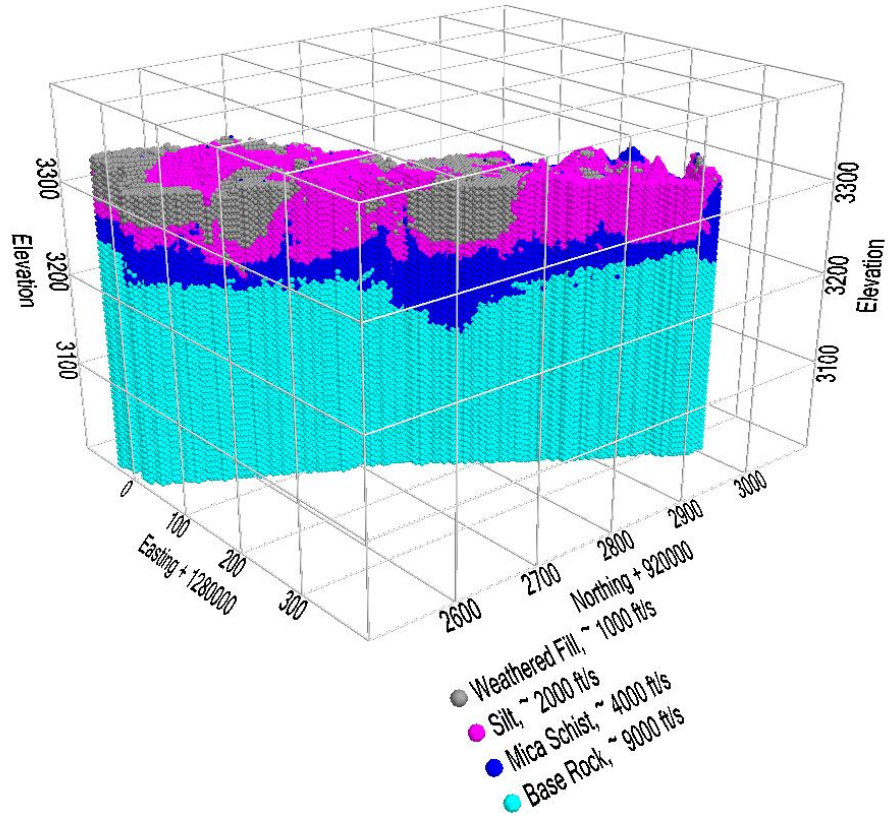


Figure 3. Refraction Tomogram Material Model

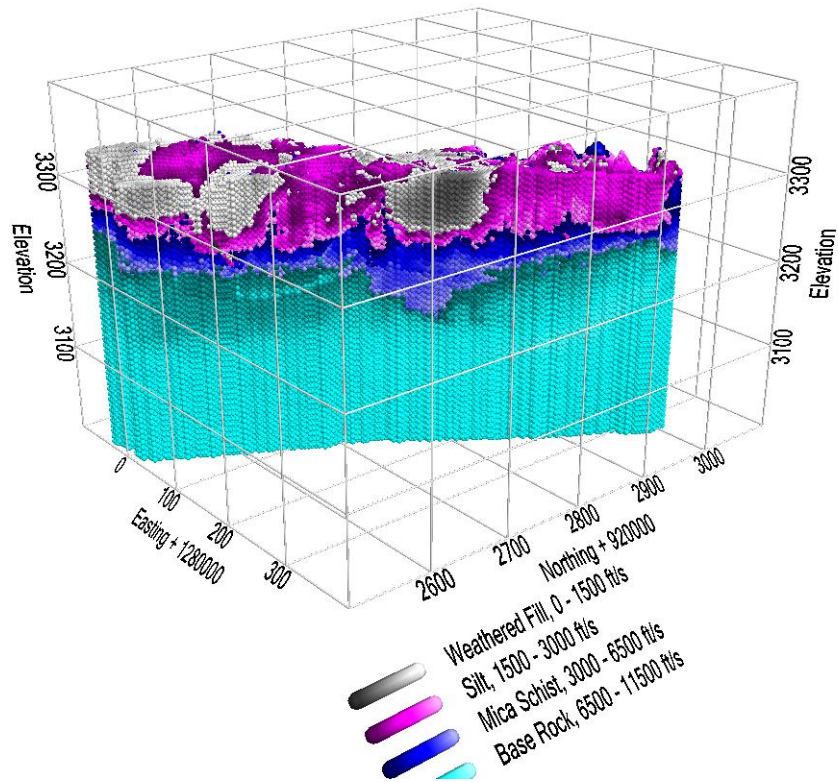


Figure 4. Velocity Variations within Layers

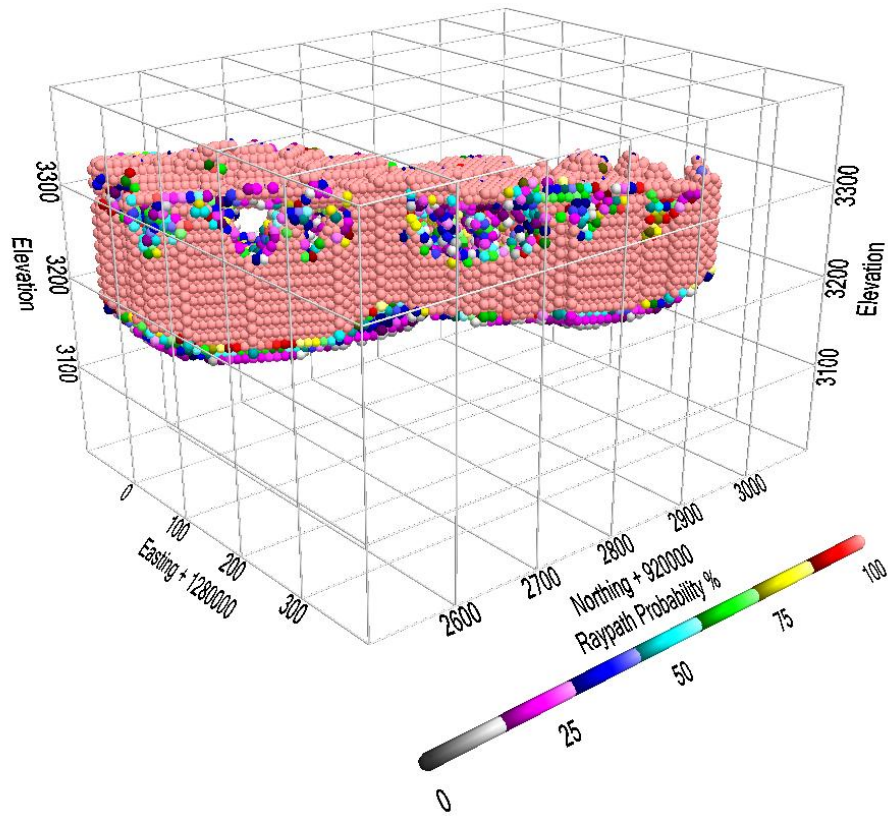


Figure 5. Ray-path Coverage.

Table 1. Top of Layer Elevations at Receiver Stations.

| Rcv Name | G-1 A | G-2 A | G-3 A | G-4 A | G-5 A | G-6 A | G-7 A | G-8 A | G-9 A | G-10 A | G-11 A | G-12 A |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Northing | 922952 | 922933 | 922920 | 922901 | 922884 | 922866 | 922855 | 922836 | 922820 | 922809 | 922791 | 922776 |
| Easting | 1280276 | 1280266 | 1280251 | 1280243 | 1280229 | 1280216 | 1280201 | 1280189 | 1280179 | 1280168 | 1280154 | 1280140 |
| Elevation | 3297 | 3303 | 3306 | 3304 | 3310 | 3315 | 3306 | 3304 | 3305 | 3302 | 3318 | 3315 |
| Weathered Fill ~ 1000 ft/s | | 3303 | 3306 | 3304 | | | 3306 | 3304 | 3305 | 3302 | 3318 | 3315 |
| Silt ~ 2000 ft/s | 3297 | 3300 | 3302 | 3290 | 3310 | 3315 | 3290 | 3248 | 3244 | 3242 | 3243 | 3242 |
| Mica Schist ~ 4000 ft/s | 3235 | 3234 | 3236 | 3234 | 3234 | 3234 | 3235 | 3230 | 3228 | 3227 | 3228 | 3228 |
| Base Rock ~ 9000 ft/s | 3214 | 3210 | 3189 | 3194 | 3200 | 3143 | 3142 | 3142 | 3142 | 3142 | 3152 | 3162 |

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| Rcv Name | G-1 a | G-2 a | G-3 a | G-4 a | G-5 a | G-6 a | G-7 a | G-8 a | G-9 a | G-10 a | G-11 a | G-12 a |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Northing | 922776 | 922756 | 922744 | 922727 | 922711 | 922689 | 922663 | 922648 | 922628 | 922612 | 922599 | 922579 |
| Easting | 1280135 | 1280134 | 1280120 | 1280118 | 1280106 | 1280107 | 1280092 | 1280083 | 1280077 | 1280060 | 1280049 | 1280039 |
| Elevation | 3312 | 3320 | 3306 | 3313 | 3310 | 3302 | 3321 | 3310 | 3315 | 3316 | 3302 | 3311 |
| Weathered Fill ~ 1000 ft/s | 3312 | 3320 | 3306 | 3313 | 3310 | | 3321 | 3310 | 3315 | 3316 | 3302 | 3311 |
| Silt ~ 2000 ft/s | 3243 | 3244 | 3247 | 3262 | 3274 | 3302 | 3290 | 3306 | 3273 | 3249 | 3248 | 3254 |
| Mica Schist ~ 4000 ft/s | 3228 | 3228 | 3230 | 3243 | 3230 | 3242 | 3226 | 3230 | 3234 | 3229 | 3226 | 3226 |
| Base Rock ~ 9000 ft/s | 3166 | 3175 | 3192 | 3202 | 3198 | 3208 | 3206 | 3211 | 3206 | 3206 | 3208 | 3208 |

| Rcv Name | G-1 B | G-2 B | G-3 B | G-4 B | G-5 B | G-6 B | G-7 B | G-8 B | G-9 B | G-10 B | G-11 B | G-12 B |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Northing | 922525 | 922543 | 922547 | 922573 | 922585 | 922593 | 922623 | 922649 | 922651 | 922672 | 922674 | 922715 |
| Easting | 1279967 | 1279978 | 1279985 | 1279995 | 1280018 | 1280033 | 1280030 | 1280035 | 1280041 | 1280056 | 1280092 | 1280070 |
| Elevation | 3337 | 3337 | 3335 | 3340 | 3344 | 3347 | 3352 | 3343 | 3344 | 3338 | 3330 | 3326 |
| Weathered Fill ~ 1000 ft/s | 3337 | 3337 | 3335 | 3340 | 3344 | 3347 | 3352 | 3343 | 3344 | 3338 | 3330 | 3326 |
| Silt ~ 2000 ft/s | 3294 | 3281 | 3278 | 3278 | 3246 | 3248 | 3249 | 3248 | 3247 | 3245 | 3242 | 3243 |
| Mica Schist ~ 4000 ft/s | 3281 | 3266 | 3262 | 3243 | 3226 | 3227 | 3228 | 3229 | 3229 | 3228 | 3227 | 3227 |
| Base Rock ~ 9000 ft/s | 3243 | 3213 | 3213 | 3209 | 3204 | 3203 | 3194 | 3194 | 3189 | 3189 | 3210 | 3202 |

| Rcv Name | G-1 C | G-2 C | G-3 C | G-4 C | G-5 C | G-6 C | G-7 C | G-8 C | G-9 C | G-10 C | G-11 C | G-12 C |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Northing | 922995 | 922983 | 922973 | 922957 | 922940 | 922925 | 922913 | 922897 | 922891 | 922874 | 922866 | 922853 |
| Easting | 1280309 | 1280291 | 1280275 | 1280257 | 1280246 | 1280235 | 1280223 | 1280198 | 1280188 | 1280169 | 1280162 | 1280147 |
| Elevation | 3326 | 3297 | 3300 | 3325 | 3300 | 3325 | 3325 | 3299 | 3299 | 3299 | 3312 | 3310 |
| Weathered Fill ~ 1000 ft/s | 3326 | | | | | | 3325 | 3299 | 3299 | 3299 | 3312 | 3310 |
| Silt ~ 2000 ft/s | 3285 | 3297 | 3300 | 3325 | 3300 | 3325 | 3302 | 3296 | 3298 | 3298 | 3293 | 3298 |
| Mica Schist ~ 4000 ft/s | 3253 | 3238 | 3241 | 3243 | 3234 | 3236 | 3238 | 3246 | 3270 | 3270 | 3274 | 3252 |
| Base Rock ~ 9000 ft/s | 3227 | 3218 | 3214 | 3211 | 3204 | 3206 | 3204 | 3207 | 3218 | 3190 | 3164 | 3170 |

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