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SEISMIC REFRACTION INTERPRETATION WITH VELOCITY GRADIENT AND DEPTH OF INVESTIGATION

Michael L. Rucker

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For Dr.Oncel
By
Ahmed Al-Zawwad
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- Two questions:
- First, what is the depth of investigation of a seismic survey?
- Second, what alternative interpretations are available when the subsurface geology is not modeled well as a traditional layered media?

Introduction

- Subsurface geology is traditionally visualized as a layered media when results from seismic refraction surveys are applied to geotechnical engineering applications.
- the development of computer lead the practical seismographs for civil engineering use.

Non-linear Optimization

-The non-linear optimization interpretation includes gradual velocity changes.

-includes an explicit interpretation of travel paths for the first arrival seismic energy passing through the subsurface.

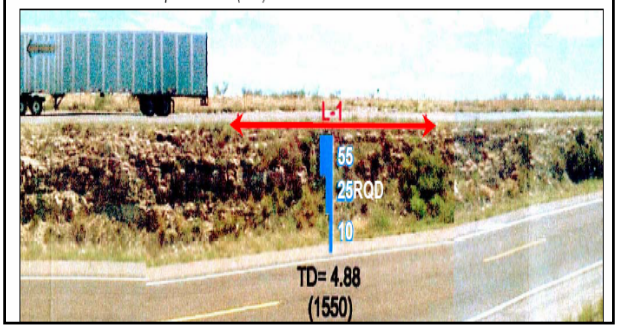
Interpretation Concepts

- There is two primary interpretation methods:

1) velocity gradient interpretation is represented by non-linear optimization.

2)traditional layered interpretation is represented by the intercept-time method.

Figure 2. *Example ITM interpretation with apparent depth of investigation from optimization interpretation. Upper photo shows exposed limestone at the proposed excavation cut. The center plot shows the ITM and depth of investigation interpretation. The lower plot shows the time-distance plots for the seismic first arrival data. Project units are metric, and seismic wave velocities are in meters per second (m/s).*



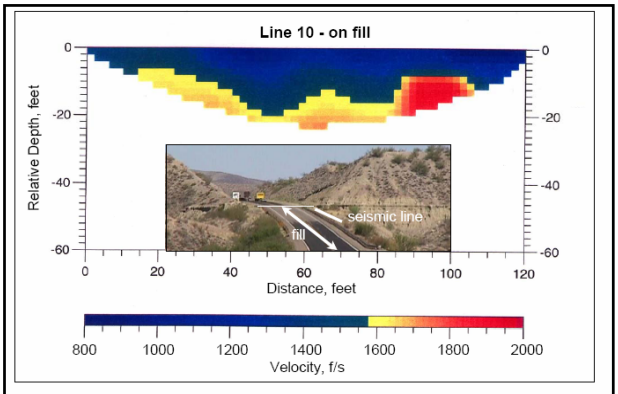
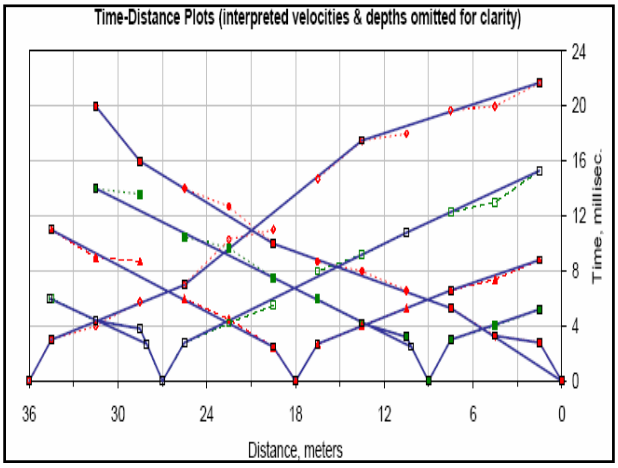
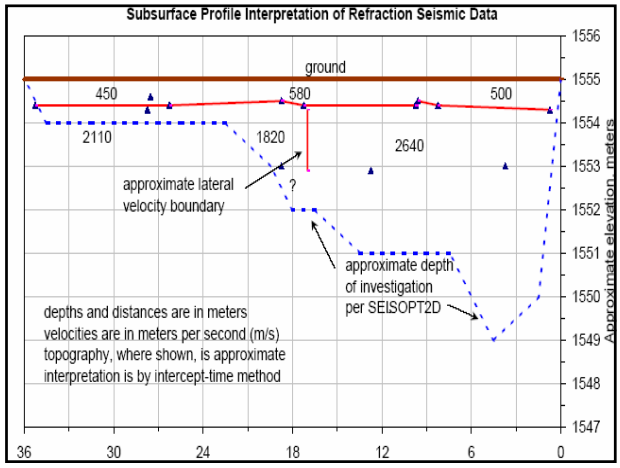


Figure 1. *Example seismic refraction interpretation using non-linear optimization software. Field data was acquired using a 12-channel seismograph with 10-foot geophone spacing. The seismic line was deployed on an engineered fill adjacent to a cut slope. Seismic wave velocities are in feet per second (f/s).*





Depth of Investigation

Depth of investigation is a basic investigation parameter that is frequently misunderstood

The idea of depth of investigation can be separated into two concepts:

Intercept-Time Method (ITM)

-Interpretation by ITM assumes that the subsurface material layers are present

-each layer has a uniform velocity

-Velocities are interpreted by determining straight-line slopes along the various portions of a time-distance plot of the arrival of the first seismic signal.

There is three types of depth investigation:

1) **Apparent Depth of Investigation**

2) Implied Depth of Investigation

3) **Interpreting Depths of Investigation**

1) the depth of investigation is confined to the zone through which the seismic energy detected as first arrivals actually passes.

2) field parameters such as source strength and geophone array limit detecting refracted first arrival energy from deeper high velocity layers.

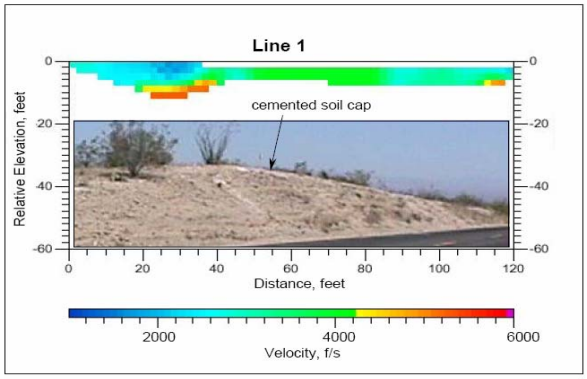


Figure 4. *Example optimization interpretation showing very shallow depth of investigation due to a cemented soil cap overlying old basin alluvium deposits. The ITM interpretation (not shown) resulted in velocities of about 4,700 f/s beginning at depths of 1 to 4 feet.*

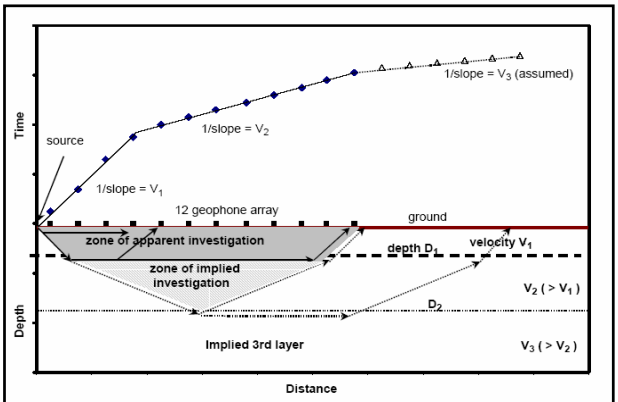


Figure 3. *Conceptual ITM interpretation of apparent and implied depths of investigation. A 12 geophone array with seismic energy source at the end is assumed. Only slopes V_1 and V_2 can be derived from the seismic waves detected by the geophone array. Velocities within each subsurface layer are assumed to be uniform.*

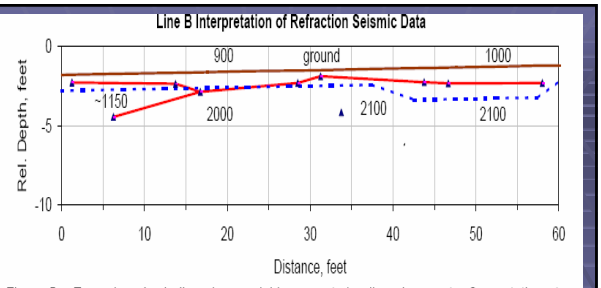
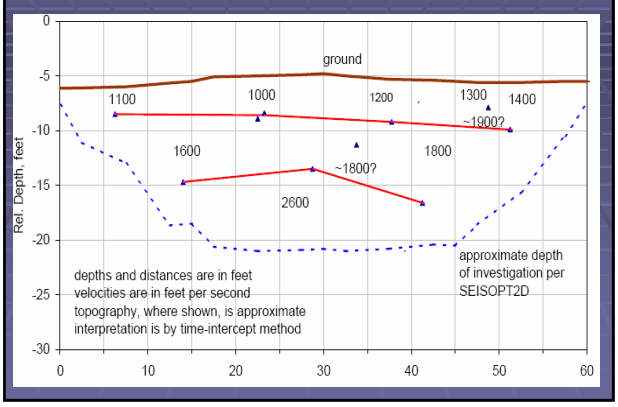


Figure 5. *Example seismic lines in a variably cemented soil environment. Cementation at a depth of 2 to 4 feet is visible in the upper photo in an arroyo wall near Lines A and B. Line A indicates an area with relatively less cementation (lower velocities below depth of 2 feet) and a relatively deep apparent depth of investigation. Line B indicates an area with significant cementation (higher velocities) at a depth of about 2 feet and a very shallow apparent depth of investigation. Interpretation depth scales are relative to the project reference elevation.*

Velocity Gradient Interpretation



Conclusion

-New software capabilities that perform interpretations as velocity gradients are improving the ability to include depths of investigation in seismic refraction interpretations.

-Identification of cohesion less versus cohesive soil deposits (above the water table) may be possible utilizing velocity gradients.

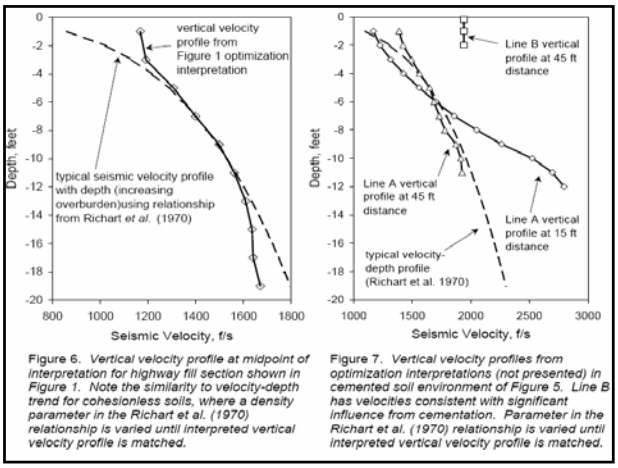


Figure 6. *Vertical velocity profile at midpoint of interpretation for highway fill section shown in Figure 1. Note the similarity to velocity-depth trend for cohesionless soils, where a density parameter in the Richart et al. (1970) relationship is varied until interpreted vertical velocity profile is matched.*

Figure 7. *Vertical velocity profiles from optimization interpretations (not presented) in cemented soil environment of Figure 5. Line B has velocities consistent with significant influence from cementation. Parameter in the Richart et al. (1970) relationship is varied until interpreted vertical velocity profile is matched.*