



Geophysical Services

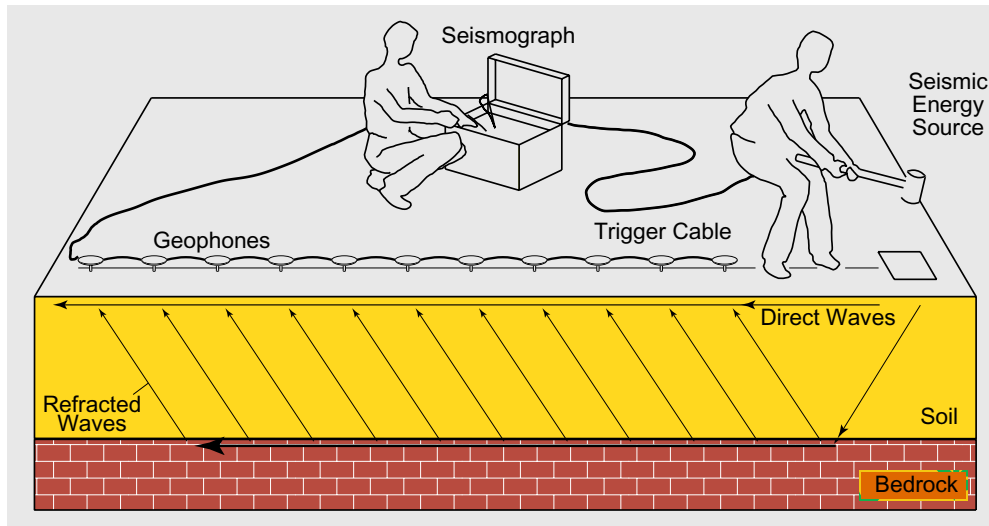
Environmental • Groundwater • Geotechnical

Seismic Refraction



SEISMIC REFRACTION SURVEYS

Depth-to-Bedrock
Competence of Bedrock
Fault Mapping
Groundwater Investigations



from: Benson, 1983

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Seismic Refraction

Seismic refraction is a commonly used geophysical technique to determine depth-to-bedrock, competence of bedrock, depth to the water table, or depth to other seismic velocity boundaries.

PHYSICAL PRINCIPLES

The seismic refraction technique is illustrated in the photos and schematic drawing on the attached sheet. An impulsive source creates a seismic wave (sound wave) which travels through the earth. When the wave-front reaches a layer of higher velocity (e.g. bedrock) a portion of the energy is refracted, or bent, and travels along the refractor as a “head wave” at the velocity of the refractor (bedrock). Energy from the propagating head wave leaves the refractor at the “critical angle” of refraction and returns to the surface, where its arrival is detected by a series of geophones and recorded on a seismograph. The angle of refraction depends on the ratio of velocities in the two materials (Snell’s Law). Travel times for the impulsive wave-front to reach each geophone are measured from the seismograph records. From those travel times, seismic velocities in each layer, and depths to each layer can be calculated.

FIELD PROCEDURES

Each seismic refraction “spread” consists of a series of 12 or 24 geophones placed along the line at a set distance or “geophone interval.” The geophone interval is generally 10 to 50 feet depending on the desired resolution and the desired depth of exploration. Due to the geometry of refraction (governed by Snell’s Law), it is necessary for the length of the seismic “spread” to be approximately 3 to 5 times the depth of the overburden in order to detect the primary refractor (i.e., the bedrock).

A series of 5 to 7 “shots” are initiated for each spread, one at each end, one or more beyond the ends (“off end”), and one or more along the spread. These additional “shotpoints” allow dipping interfaces, changes in overburden materials, and intermediate

layers to be identified and resolved. Hence the additional intermediate shotpoints increase the accuracy of the depth-to-bedrock interpretation. Several spreads may be put together to form a longer refraction profile line.

Several options are available for the impulsive seismic source. A sledge hammer as an energy source may be effective if the bedrock is not deeper than 20 or 25 feet, and if the overburden is sufficiently consolidated. A higher energy source, such as 8-gauge seismic shells or small charges of a two-component explosive, may be required if the overburden is loose and poorly consolidated, or if the bedrock interface is significantly deeper.

APPLICATIONS

The product or “deliverable” from a seismic refraction survey is generally a profile, or cross section, along the seismic line showing depth-to-bedrock (or other primary refractor) at each geophone, and seismic velocities in the bedrock and the “overburden.” Often layers with intermediate velocities (corresponding to layers or units with varying consolidation or lithology) can be identified and resolved.

Seismic velocities relate to the “soundness” or competence of rock, and to the degree of consolidation, cementation, and/or saturation in soils. The Caterpillar Tractor Co. has developed a series of tables which empirically relate seismic velocities to the “rippability” of bedrock with their equipment (such as a D8 or D9 with one or several ripper teeth).

In geotechnical engineering, depth-to-bedrock and rippability surveys are commonly used for design and cost estimates for road cuts, pipelines, and other civil engineering projects. Groundwater applications of seismic refraction include mapping bedrock channels, identifying faults and fracture zones, and delineation of geologic boundaries to constrain hydrogeologic models.

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