MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

Methodology

When seismic energy is produced at or near the ground surface, both body and surface waves are generated. Body waves consist of both compressional (P) and shear (S) waves. Surface waves (e.g., Rayleigh, Love, etc.) propagate at velocities that are proportional to shear wave velocity (Vs). If a vertical energy source is used, Rayleigh type surface waves are produced. These are commonly referred to as ground roll in seismic surveys. Rayleigh waves are retrograde elliptical and travel at approximately 0.9 times the velocity of S-waves.

MASW data are gathered in much the same way as high resolution reflection data. Seismic energy generated by vertical impacts on the ground surface are detected by an array of closely spaced geophones. The energy source and the geophones are sequentially moved along a profile as the survey progresses. The primary differences are that the surface wave technique requires an energy source that is capable of producing ground roll and geophones that are capable of detecting low frequency (<10 Hz) signals.

Surface waves account for more than two-thirds of the energy produced by vertical impact seismic energy sources. As a result, surface waves are the most prominent signal on multi-channel seismic records. In addition, surface waves have dispersion properties that body waves lack. That is, different wavelengths have different penetration depths and, therefore, propagate at different velocities. By analyzing the dispersion of surface waves it is possible to obtain a near-surface S-wave velocity profile. Since S-wave velocity is directly proportional to shear modulus, this provides a direct indication in the variation of stiffness (or rigidity) of subsurface materials.

Data Acquisition

We collect MASW data using a Geometrics Geode 24-channel seismograph, an I/O Rotalong Roll-Box, two 24-take out CMP cables, and 48 8-Hz geophones. The geophonesare distributed at 3 or 4 foot intervals along the seismic line and connected to the roll box via the CMP cables. The roll box, which is connected to the seismograph, enables us to record the signals from 24 contiguous geophones with each shot. Typically, the shot point is moved along the seismic line at 6 or 8 foot intervals, and the roll-box is used to activate 24 of the 48 geophones starting 24 feet in front of the shot point. For example, for the first shot the shot point is placed 24 feet from the first geophone, and geophones 1 through 24 are active. For the second shot, the shot point is again placed 24 feet from the first *active* geophone, but in this instance geophones 3 through 26 are activated, and so on. Once the active 24-geophone spread reaches the end of the 48-geophone array, the first 24-geophones in the array are moved to the end of the array, and the procedure is continued. We produce seismic energy at each shot point using a 16-pound sledgehammer striking a metal plate placed on the ground surface.

Data Analysis

We interpret MASW data using the computer program ***Surfseis***, which was developed by the Kansas Geological Survey. The software analyzes the data from each seismic shot gather and determines the variation in Rayleigh wave velocity versus frequency to form what is referred to as a “dispersion curve”. The software then inverts the dispersion curve to produce a 1-D model representing the variation is S-wave velocity with depth beneath the center of the active 24-geophone array for that particular shot. We then collate the data from all of the individual 1-D velocity models along the seismic line to form a 2-D cross-section representing the variation in S-wave velocity with depth and distance along the seismic line. We contour and shade the 2-D sections using the computer program ***Surfer***, by Golden Software, Ltd.