Compressional and shear wave examples of near-surface seismic methods for hydrogeophysical applications

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High-resolution near-surface seismic reflection methods have been used for an array of applications, including determining depth to bedrock or the water table, void detection, delineating near-surface stratigraphy, fault identification, and identifying contaminant sinks or pathways, to name a few. Accurately imaging shallow depths using seismic methods provides another tool to complement other techniques, such as GPR, electromagnetic, electrical, etc., or to use when other methods are not successful. Surface seismic methods are non-invasive and may be desired when characterizing contaminated areas where the installation of monitoring wells or boreholes may exacerbate the problem by providing conduits for contaminants to flow from one stratum to another.

With the field of hydrogeophysics continuing to grow, the use of high-resolution near-surface seismic surveys may become even more important. A well-executed seismic program may allow the identification of preferential flowpaths and/or sinks where contaminants can migrate and pool and help optimize the placement of wells for specific targets, reducing the time and costs associated with drilling unnecessary wells. The high costs inherent to the acquisition and processing of seismic reflection data may preclude the method as an economical option; however, as the need for protection and development of water resources grows, and as the capability of cost-effective engineering-scale seismographs improves, these methods may become a more viable option.

High-resolution compressional- (P) and shear- (S) wave methods can be used to image small-scale features in the subsurface, including near-surface stratigraphy, faults, and paleo-channels. P-wave methods are typically used more often due to the higher frequencies that can be generated and recorded, however; S-waves have the potential for increased seismic resolution in water-saturated sediments. S-waves are generally (but not always) lower frequency than their P-wave counterparts, but the associated lower velocities (~60% of V_p) can yield higher resolution in saturated near-surface materials due to shorter wavelengths, which can be especially beneficial in unconsolidated sediments. Recent studies have shown the effectiveness of utilizing S-wave seismic reflection methods to image shallow deformation in the poorly consolidated sediments of the lower Mississippi embayment, including shallow faults and flow paths through aquitards.

We will show both compressional and shear wave seismic reflection examples that demonstrate the ability to characterize the subsurface structure in different geologic settings that could be beneficial to hydrogeophysical applications by defining stratigraphy, flow paths, and depositional features.