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MASW Analysis of Bedrock Velocities from Refractions as Higher Modes

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It is generally known that surface waves are formed through the interference of direct and mode-converted reflections and refractions of P and S waves. The dispersion analysis adopted in the multichannel analysis of surface waves (MASW) is based on the 2-D wavefield transformation that delineates the frequency dependency of velocity for all horizontally travelling seismic waves. The transformation naturally includes P- and S-wave refractions from velocity interfaces, the most important one of which is the overburden-bedrock boundary.

Through the reflectivity modeling of MASW records and subsequent wavefield transformation, it is shown that these refraction events actually consist of higher modes of surface waves that usually occur at much higher frequencies than the fundamental mode. The vertical impact source generates not only those P waves refracted from the bedrock surface that are usually recorded as first arrivals, it also generates refracted S waves from the PS conversion that often possess an energy level comparable to that of the refracted P waves. These S waves arrive later and get mixed with multiples and PS converted reflections — the place in the seismogram where it is usually interpreted as a zone of "surface waves."

Observation of these special higher modes during the MASW dispersion analysis can provide a powerful tool to estimate bedrock velocities (Vp and Vs), which have been challenging especially for deep (e.g., ≥ 10 m) bedrock. Theoretical overview is provided first and actual field-data examples are presented. It is also discussed that the "near-field effect" of surface waves are fundamentally related to the critical distance for refraction to occur.