Crosshole GPR full-waveform inversion to characterize the aquifer of the Boise Hydrogeophysical Research Site

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Decimeter-scale high contrast layers caused by increased porosity or clay content are important because they can have a dominant effect on solute transport. Recently, we demonstrated by means of a GPR field example of a gravel aquifer close to the Thur River (Widen, Switzerland) that layers characterized by high dielectric permittivity can act as low velocity electromagnetic waveguides and be readily identified and characterized using high-frequency crosshole ground penetrating radar (GPR). Figure 1a shows experimental data measured at the Widen site that for a transmitter present within the waveguide, high amplitude elongated wave trains are detected by receivers straddling the waveguide depth range, with significantly larger amplitudes than on receivers outside the low velocity duct. Analysis of the BHRS GPR homework data showed that similar characteristics can be observed as shown in Figure 1b.

Ray-based inversion techniques are not able to image such thin waveguide layers because they only exploit the first-arrival times and first-cycle amplitudes and ignore the high amplitude late arrival characteristic for the presence of a waveguide (see also Figure 1). In contrary, full-waveform inversion exploits the full information content of the data and is therefore able to image a sub-wavelength thickness low-velocity wave-guiding layer as shown for the Widen data (Klotzsche et al., Geophysics, accepted).

The full-waveform inversion will also be applied on the BHRS homework dataset to achieve sub-wavelength resolution images for the crosshole GPR data set. Preliminary inversion results indicate that the waveguide indicated by the high amplitudes in Figure 1b is not present over the whole horizontal range of the crosshole plane, but is only present for part of the horizontal range.

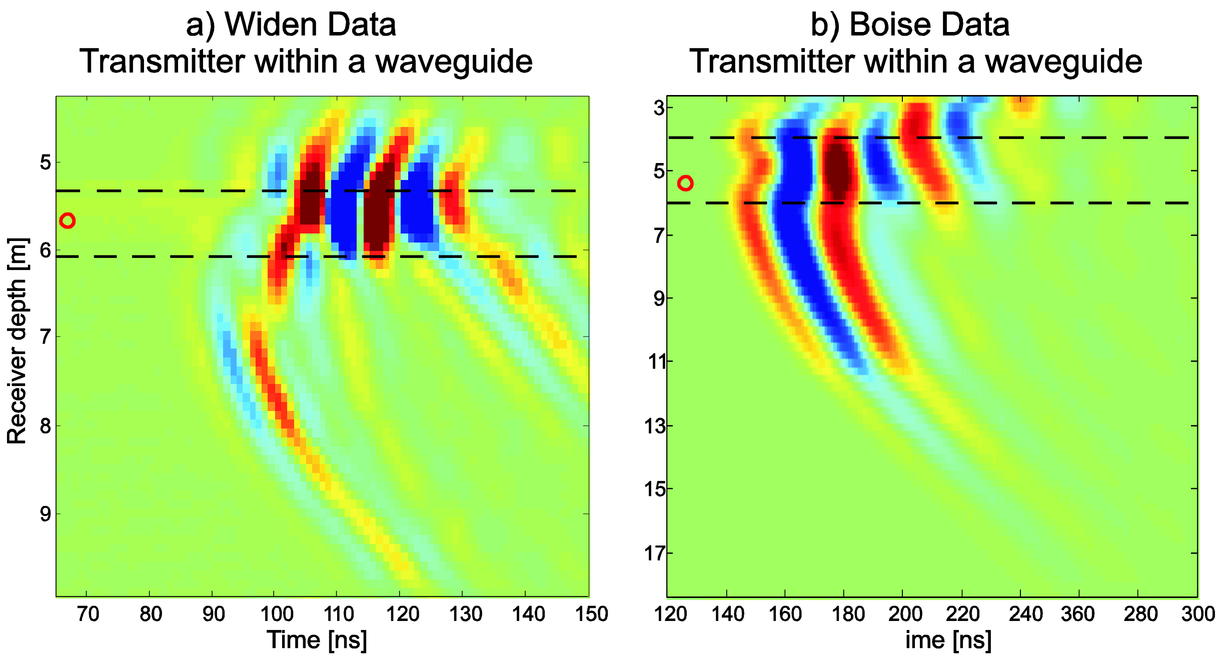

Figure 1: Experimental data where a transmitter is located within a low-velocity waveguide (indicated by black dashed lines) for the a) Widen (Switzerland) and b) Boise homework data. Note the high elongated amplitudes for receiver depth along the waveguide, whereas the amplitudes outside the wave guiding layer are decreased. The red circle indicates the transmitter position.