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Exploring the potential of 3D diffraction imaging for GPR data

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Diffraction imaging has become an established tool in exploration seismology thanks to its potential to provide high-resolution information that is complementary to that contained in the corresponding reflected wavefield. In ground-penetrating radar (GPR) research, data processing schemes often neglect the diffracted wavefield, focusing instead on higher-amplitude reflected arrivals. However, these data typically contain a rich diffraction background due to the structural complexity of the near surface environment. Whereas the application of diffraction imaging to 2D GPR data has already been demonstrated, the potential of diffraction imaging for 3D GPR data is still underexplored.

Building on recent studies, we adapt a coherence-based diffraction imaging workflow, originally designed for seismic data, to common-offset GPR data. The first step of the proposed scheme is the separation of diffracted arrivals from the often predominant reflections, i.e. the faint diffracted portion of the data is separated and made accessible for dedicated processing. To this end, we approximate the reflected wavefield in a fully data-driven fashion by means of a coherent stacking scheme, and we subtract it from the data. The remaining diffracted wavefield can then be further enhanced through a second local coherent stacking procedure. Ultimately, wavefield focusing of the diffraction-only data yields an image of the distribution of subsurface scatterers.

The above-described analysis is applied to a range of 3D GPR data sets in an exploratory fashion. The localization of diffracting structures in these data sets provides valuable additional information about small-scale subsurface heterogeneities that can complement standard reflection analyses.