GPR Data Migration via PWD and RDM Techniques

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Abstract

Migration is an important but often neglected step in processing Ground Penetrating Radar (GPR) data. It is essential for reconstructing high-resolution images of subsurface structures from raw data. In GPR applications, migration corrects geometric distortions and enhances the resolution of radargrams, enabling a more precise interpretation of geological features. Improving GPR image quality can significantly impact various applications, ranging from geological exploration to detecting buried infrastructure such as pipelines and cables.

Diffraction events in GPR data are caused by heterogeneities such as fractures, faults, and discontinuities, as well as artificial structures like pipelines and tunnels. Traditionally, these diffractions are treated as noise and suppressed during migration. However, accurate detection and interpretation of diffractions are critical for comprehensively understanding subsurface properties. While hyperbolic velocity analysis is standard in GPR, the resulting velocity models are often simplistic and insufficient for accurate data migration. This underscores the need for advanced migration methodologies to delineate subsurface features better and reduce interpretative ambiguity, which is vital in geophysical studies.

In this study, we present an advanced technique for identifying diffractions to derive velocity models used in the depth migration of GPR data. Initially, synthetic GPR data were utilized to validate the proposed methodology. Subsequently, we applied the Plane Wave Destruction (PWD) technique to differentiate diffractions from reflections. PWD works on the principle that plane waves (associated with reflections) and diffracted waves (related to small-scale heterogeneities) exhibit different moveout characteristics. By applying filters that suppress plane wave components, PWD enhances the visibility of diffracted waves, which is essential for accurate velocity model building.

In conjunction with PWD, we employed the Residual Diffraction Moveout (RDM) method to focus on the residual moveout of diffractions. RDM involves analyzing the residual moveout of diffracted waves that remain unfocused after initial migration. This method aids in fine-tuning the velocity model by iteratively adjusting it to minimize the residual moveout, thereby facilitating the construction of more accurate velocity models.

This iterative process involves continuous adjustments until the data are accurately migrated with a robust velocity model. The combined application of PWD and RDM techniques allows for a more apparent distinction between diffractions and reflections, enhancing the accuracy of the velocity models.

The migration and validation methodology was tested on synthetic data; after that, all the processing was applied to Real GPR data acquired from the coastal sedimentary region of Salinópolis, PA. Preliminary results indicate substantial improvements in applying these techniques to GPR data, mirroring benefits observed in reflection seismology. This enhances final image quality and facilitates a more detailed and precise interpretation of geological structures. Ultimately, this approach aims to advance GPR data processing, offering a novel methodology within geophysical data processing and geological interpretation.