EGU22-10711
https://doi.org/10.5194/egusphere-egu22-10711
EGU General Assembly 2022

A new approach toward integrated inversion of reflection seismic and gravity datasets using deep learning

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Reflection seismic data, although sparsely distributed due to the high cost of acquisition, is the only type of data that can provide high-resolution images of the crust to reveal deep subsurface structures and the architectural complexity that may vector attention to minerally prospective regions. However, these datasets are not commonly considered in integrated geophysical inversion approaches due to computationally expensive forward modeling and inversion. Common inversion techniques on reflection seismic images are mostly utilized and developed for basin studies and have very limited application for hard-rock studies. Post-stack acoustic impedance inversions, for example, rely a lot on extracted petrophysical information along drilling borehole for depth correction purposes which are not necessarily available. Furthermore, the available techniques do not allow simple, automatic integration of seismic inversion with other geophysical datasets.

We introduce a new methodology that allows the utilization of the seismic images within the gravity inversion technique with the purpose of 3D boundary parametrization of the subsurface. The proposed workflow is a novel approach for incorporating seismic images into the integrated inversion techniques which relies on the image-ray method for depth-to-time domain conversion of seismic datasets. This algorithm uses a convolutional neural network to iterate over seismic images in time and depth domains. This iterative process is functional to compensate for the low depth resolution of the gravity datasets. We use a generalized level-set technique for gravity inversion to link the interfaces of the units with the depth-converted seismic images. The algorithm has been tested on realistic synthetic datasets generated from scenarios corresponding to different deformation histories. The preliminary results of this study suggest that post-stack seismic images can be utilized in integrated geophysical inversion algorithms without the need to run computationally expensive full wave-form inversions.