Seismic Near-surface Corrections By Use Of Airborne Electromagnetics

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Abstract

Objectives/Scope: Seismic near-surface inhomogeneities is a challenge for exploration especially in arid regions. Rapidly changing velocity across complex wadis, karsts and sand dunes obscure final seismic images. Extremely low velocity, large sand dunes could introduce pitfalls in interpreting the low-relief targets. Airborne electromagnetics (AEM) with nearly continuous sampling can map the base-of-sand BoS as a low resistivity interface. Once calibrated with existing sparse uphole data, AEM data can effectively be used as a near-surface correction tool.

Methods, Procedures, Process: We introduce a novel approach for mapping the BoS using helicopter-borne micro transient electromagnetics (microTEM). This method measures the decay rate of the secondary magnetic field as a function of time. Low resistivity substratum, called sabkha, underneath the dry aeolian sands is a sharp resistivity contrast which can be detected by AEM methods. This interface is also a sharp seismic velocity contrast between the unsaturated, unconsolidated, dry sand and more saturated and consolidated sabkha. We used a specialized electromagnetic recording system (microTEM) with sharp turn off which allowed recording of the very early decay times (0.3-40 μs) for shallow imaging.

Results, Observations, Conclusions: Acquired high resolution microTEM data were preprocessed for acquisition geometry compensation and signal to noise enhancement. Resulting inversion ready data were used in a physics-driven deep learning inversion scheme (PhyDLI) to predict the subsurface resistivity model. The machine learning model was pre-trained by using geologically expected resistivity models with their calculated forward responses as labels. The predicted models were analyzed for data misfit and high rms samples were inverted using gradient based deterministic methods. These samples are iteratively added to the original training samples hence moving the training model domain toward the field data distributions. The final predicted resistivity model was superior to a traditional deterministic model. Existing uphole data were used to calibrate the resistivity model and to choose the interface value to be associated as the BoS. The new seismic stack obtained using the microTEM resistivity based BoS showed that the new reference provided better statics corrections for short and long wavelengths and improved the seismic image compared to existing statics solutions.

Novel/Additive Information: We demonstrated a novel solution for the problem of seismic near-surface corrections by use of airborne electromagnetics and physics-based machine learning inversion. Feasibility, acquisition system and the interpretation method were designed to be applied to a large exploration block characterized by a continuous sand coverage.
Given the ease of application and the demonstrated success, we envisage further research in this field for integrating AEM in seismic near-surface correction workflows.