

# **Reservoir Monitoring with Controlled-Source EM: New Advances in Acquisition and Machine Learning Interpretation**

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## **Abstract**

Reservoir monitoring during oil and gas production, EOR, or CO<sub>2</sub> storage or sequestration requires the interpretation of several geophysical measurements that must be combined with geology and engineering data. One of the appealing methods for monitoring reservoir fluids is electromagnetics (controlled-source or CSEM), where the resistivity parameter exhibits the greatest sensitivity to fluids and is thought to be relatively unaffected by other reservoir dynamic changes, particularly changes in elastic parameters and stress, although it may be affected by changes in porosity. We analyze the visibility of the application of CSEM by considering new advances in acquisition and interpretation. Advances in acquisition design indicate effective CSEM monitoring applications should use borehole technologies, such as cross-well configurations for 2D applications or surface-to-borehole configurations for 3D applications. We demonstrate the application of CSEM using an industry-first 3D surface-to-borehole experiment to monitor the injection of water. Also, advances in machine learning (ML) interpretation capability is demonstrated to explore the sensitivity of CSEM for a cross-well acquisition configurations. The application demonstrates the neural network is capable to predict the fluid distributions also in presence of noise.