Towards joint inversion of electromagnetic, seismic, and production data for reservoir characterization and monitoring

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There are variety of measurements that may illuminate the reservoir with varying coverage and resolution such as: Electromagnetic (EM) (controlled-source EM (CSEM), magnetotelluric (MT), surface to borehole (STB), and cross-well EM), Seismic (surface seismic, cross-well seismic and vertical seismic profiling (VSP)), gravity (surface and borehole), and production history/well testing data. Each measurement on its own will provide incomplete information due to the non-uniqueness and limited spatial resolution associated with their interpretations. However, when they are integrated together and combined with other measurements such as near-wellbore data, they may provide considerable values: to enable inference of pertinent reservoir properties, to enhance the predictive capacity of a reservoir model, and to help us in making appropriate field management decisions with reduced uncertainty.

In this presentation, we will present an overview of joint inversion approaches for integrating EM, seismic, and production data. For reservoir characterization applications, we will present both joint structural and petrophysical algorithms for integrating EM and seismic data (CSEM & surface seismic and cross-well EM & cross-well seismic). For reservoir monitoring applications we will present EM data (both for cross-well and STB) inversion algorithms constrained by the fluid-flow simulator (ECLIPSE). In the inversion for both EM and seismic we employ full nonlinear approach (or the so-called full-waveform inversion) so that we can utilize all the information from the data. We will also discuss challenges, advantages, and disadvantages of these approaches by using some test cases.