Time Lapse Charged Wellbore Casing Controlled Source Electromagnetic Surveys for Monitoring Injected Carbon Dioxide

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Abstract

Carbon dioxide (CO_2) injection for enhanced oil recovery (EOR) and long-term carbon storage extends the life of an oil field while keeping CO_2 out of the atmosphere. Monitoring CO_2 migration during EOR operations is critical to maximizing production and detecting CO_2 leaks quickly. We monitor CO_2 migration using time-lapse charged well casing controlled source electromagnetics (CSEM) at the Bell Creek oil field in Montana. Since CO_2 alters the electrical conductivity, this novel survey technique aims to monitor CO_2 effectively and unobtrusively from the surface via electromagnetic field measurements. Of four time-lapse field campaigns spaced over two years, we have completed two, and will complete a third by the time of the AGU meeting. Each campaign of the time-lapse survey consists of a CSEM survey, supplemented by time-domain electromagnetic and magnetotelluric surveys. In the CSEM survey, a transmitter delivers low frequency alternating current to the subsurface using steel well casings as electrodes. Receiver stations measure components of the electric and magnetic fields. The measurements are repeated at the same locations in each field campaign. Data differences between campaigns provide information about changes in the electrical conductivity in the subsurface. Charged well casing surveys detect deeper conductivity contrasts than surveys that use surface electrodes, meaning that CO_2 movement at the depth of the reservoir can be imaged more clearly. We present the the latest results from this ongoing project, including preliminary modeling, survey design, data from multiple field campaigns, and data processing techniques.