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2017 Distinguished Instructor Short Course | Doug Oldenburg

Geophysical Electromagnetics: Fundamentals and Applications

Overview

Electromagnetics has applications in oil and gas exploration and production, mineral exploration, groundwater exploration and monitoring, geotechnical, and environmental industries. Although it has widespread applications as a geophysical technique, it is not generally understood by the geoscience community. As a result *it is underutilized, and in some cases, misused, as a technology.*

The aim of this course is to provide a fundamental understanding about EM geophysics so that practitioners can decide if an EM technique can help solve their problem, select which type of survey to employ, and set realistic expectations for what information can be gleaned. Case histories, spanning applications from many areas in the geosciences, are used as an underlying framework to bind the material together.

Content: Fundamentals and Applications

Case histories pertain to problems in resource exploration, including oil and gas, minerals, water, environmental, and geotechnical areas and are contributed by experts worldwide.
These include:

- resource detection (e.g. methane hydrates) or de-risking (e.g. offshore-hydrocarbons),
- imaging SAGD steam chambers or monitoring hydraulic fracturing,
- mineral exploration (on land, on the ocean floor sea floor massive sulfides),
- water issues (e.g. monitoring salt water intrusion, imaging aquifers),
- imaging geothermal systems,
- detecting and discriminating unexploded ordnance,
- geotechnical characterization, including slope stability

We use these applications as motivation for investigating fundamentals of electromagnetics. We successively look at applications that make use of:

- Steady state fields (e.g. DC resistivity, induced polarization)
- Frequency domain EM (e.g. marine CSEM, airborne surveys)
- Time domain EM (e.g. airborne, ground, borehole surveys)
- Natural source EM (e.g. Magnetotellurics, Z-Axis Tipper / ZTEM)

The energy sources for these surveys can be man-made or natural. Man-made sources include inductive transmitters (loops of wire carrying a current) or galvanic sources where current is injected into the ground. The natural energy sources promote MT (magnetotellurics), which is important for characterizing deep conductivity structures for geothermal energy, and ZTEM, which has proven to be valuable in geologic mapping and mineral exploration. The various surveys can be carried out in the air using helicopters or airplanes, on the earth's surface, or underground; the geoscientific question to be addressed determines which survey is selected. Case histories and survey types presented will be tailored to each location at which the DISC is presented, and chosen based on the local problems of general interest.

DISC 2017

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The goal of the 2017 DISC is to provide fundamental understanding about EM geophysics so that practitioners can decide if an EM technique can help solve their problem, select which type of survey to employ, and set realistic expectations for what information can be gleaned. Case histories, spanning applications from many areas in the geosciences, are used as an underlying framework to bind the material together.

Each case history is presented in a seven-step process that begins with the description of the geologic or geophysical problem to be solved and ends with the impact of the EM geophysical survey to help solve the problem. At points in the middle, we investigate the details of the particular EM survey, some fundamentals of electromagnetic induction, and techniques for processing/inverting the data. The ability to move seamlessly between these different levels of information, so that relevant questions or concepts can be addressed, is facilitated by new open-source numerical software, interactive simulations, and the "textbook" resource http://em.geosci.xyz. Although we work continually with Maxwell's electromagnetic equations, the presentations are mathematically "light" and the learning aspect is facilitated by the use of Jupyter notebooks, and visual aides. The case histories pertain to problems in resource exploration (oil and gas, minerals, water), environmental, and geotechnical areas, and are contributed by experts worldwide. We successively look at surveys that make use of steady state fields (e.g. DC resistivity, induced polarization) and then move on to frequency and time domain EM. The energy sources for these surveys can be man-made or natural. Man-made sources include inductive transmitters (loops of wire carrying a current) or galvanic sources where current is injected into the ground. The natural energy sources promote MT (magnetotellurics), which is important for characterizing deep conductivity structures for geothermal energy and ZTEM (Z-Axis Tipper EM), and has proven to be valuable in geologic mapping and mineral exploration. The various surveys can be carried out in the air using helicopters or airplanes, on the earth's surface, or underground, and the case history determines which survey is selected. The choice of case histories and surveys to focus on depends upon the location at which the DISC is presented and the local problems that are of general interest. Prior to any presentation we are soliciting locally generated case histories.

The 2017 DISC is designed to be of interest to a broad audience, including researchers, practitioners, and industry geoscientists, and accessible to those with little background in EM. It is not possible to cover all of EM geophysics in a single day but attendees will obtain new insight about EM fundamentals and applications. The DISC material, and the associated open source resources, can then act as a catalyst to develop a community that can share information, interact on EM problems of mutual interest, and elevate the use of EM geophysics to solve applied problems.

Who should attend?

Geophysicists and any geoscientists who have the potential to use, or be associated with, electromagnetic data. The 2017 DISC is designed to be of interest to a broad audience, including researchers, practitioners, and industry geoscientists, and accessible to those with little background in EM.

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