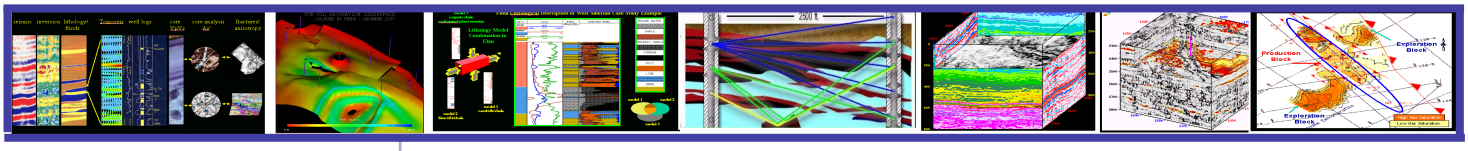
ElectroMagnetic Methods Hydrocarbon /Geothermal E&P

Training course



Course description

The specific content of this course varies for hydrocarbon or geothermal exploration and production. For hydrocarbon we include the strength of EM to resolve resistive reservoirs and marine electromagnetics. For geothermal we focus more on detecting conductive reservoir anomalies and changes

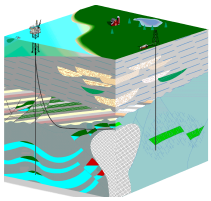
Electromagnetic techniques are important for hydrocarbon E&P because they can distinguish between oil and water saturated rock, responding directly to water-filled porosity. Electromagnetics can be applied for exploration to reservoir monitoring.

The sensitivity of EM decreases slowly with depth, so they can often be applied when seismics fails. However, their real strength lies in their complementary use, along with seismic, either to improve the seismic velocity interpretation or to provide additional information such as inferred porosities. We will introduce three techniques: Magnetotellurics (MT), frequency domain CSEM and time domain CSEM (tCSEM™). MT uses the Earth's natural electromagnetic field as its source, and makes tensorial (multi-channel) measurements to obtain information about the resistivity structure. CSEM uses its own transmitter with magnetic and/or electric field component measurements, also to obtain information about the resistivity structure. The LOTEM is closely related to CSAMT (Controlled source audio MT), which is used in mineral and hydrocarbon exploration. Each technique has an optimum depth range, which depends on the resistivity environment, with some overlap between the methods.

Magnetotellurics was developed in the fifties; today numerous manufacturers offer 24/32 bit array systems. Marine MT systems are available in marine EM service companies. LOTEM was first developed in the former Soviet Union and subsequently several digital systems were developed in the West for R&D. For commercial applications, the first multi-channel system was developed in the late 80s. The physics of MT is based on calculating the ratios between the random natural magnetic and electric field components so that the method can use the unknown source field. This ratio is an impedance tensor. It is transformed to apparent physical parameters for interpretation. In the LOTEM (or tCSEM™) case the source also generates a downward diffusing signal, causing a transient signal at the receiver sites. Knowledge of the source and geometry allows the calculating of apparent resistivities from a single field electric or magnetic component. Using the electric and magnetic components gives you different sensitivities.

Standard applications: MT is widely used in many parts of the world for a variety of applications. Its major use is for oil exploration in seismically difficult areas, including karst in east and SE Asia, and for sub-salt and sub carbonate exploration in the Mediterranean and Gulf of Mexico. At 'audio' frequencies it is used for mineral exploration at depths beyond the reach of Transient EM while, at still higher frequencies, it is being applied to a range of environmental problems. Case histories to be shown include applications in petroleum and geothermal exploration, and in environmental problems.

Numerous case histories are shown where MT, CSEM, LOTEM, and tCSEM™ measurements confirm independently other measurements and help getting better resolution in the interpretation. The applications range from hydrocarbon exploration, mineral exploration, coal applications, mapping porosities to sub-basalt exploration and deep crustal studies. The future of electromagnetic measurements lies clearly in their combination with reflection seismics to better define fluid content. In addition EM results can be used to constrain the interpretation of seismic velocities.



KMS Technologies

KJT Enterprises Inc.
6420 Richmond Ave., Suite 610
Houston, TX 77057
USA

Tel: +1.713.532.8144

Email: info@KMSTechnologies.com
www.KMSTechnologies.com

Course material and requirements

The course will provide a course website with the lectures and supporting downloads: literature, free software and previous course results (term papers etc.). Course participants will receive a password and user name. In addition the following textbooks are recommended

Strack, K.-M., 1992 & 1999, Exploration with Long Offset Transient EM, Elsevier

Vozoff, K., 1991, The Magnetotelluric Method, in Electromagnetic Methods in applied geophysics, Nabighian, M.N. (ed.), SEG.

Target audience:

Geoscientists with a basic understanding of geophysics

Course outline

Introduction, physics & methods

- History of EM methods
- Electrical properties of rocks
- Methods & instruments
- Data processing

Land EM applications

- Defining sediments, basin-scale, sub-basalt, sub-salt
- Shale applications (hydrocarbon)
- Geothermal applications (geothermal)
- Resolving resistive targets (direct hydrocarbon indicators)

Planning & survey design

- From 1D to complex 3D studies
- Planning an EM monitoring pilot

Marine EM

- Marine magnetotellurics
- CSEM
- tCSEM™

EM Logging tool basics

- New array resistivity tool
- 3D induction logging
- NMR mud logging (geothermal)

Reservoir monitoring

- Microseismic/EM monitoring

The Future