Title

Three Dimensional Interpretation Of Electromagnetic Data, A Review And Recent Advancement At LBNL

Authors

Tseng, Hung-Wen
Lee, Ki Ha
Wilt, Michael J.

Publication Date

2003-08-01

THREE DIMENSIONAL INTERPRETATION OF ELECTROMAGNETIC DATA, A REVIEW AND RECENT ADVANCEMENT AT LBNL

Hung-Wen Tseng, Ki Ha Lee, and Michael J. Wilt

Summary

Electrical conductivity is related to the porosity, pore fluid conductivity, saturation, temperature, clay content, and dissolved mineral content of most rock. This relationship justifies the use of the EM geophysical methods for geohydrology, geothermal exploration, enhanced oil recovery monitoring, engineering geophysics, and monitoring of environmental remediation processes. A cross-hole and a borehole-to-surface EM system have been completed, and an inversion code dubbed the modified extended Born approximation (MEBA) has been developed for 3-D EM inversion. The performance of the MEBA code has been verified using both synthetic and field data. In this paper we illustrate a new application with MEBA.

Traditionally, EM induction logging is widely used for directly measuring the formation conductivity surrounding uncased wells. A logging tool primarily consists of a magnetic dipole transmitter and a receiver in a coaxial configuration in line with the borehole axis. As a result of this cylindrically symmetric nature of the source and receiver, induction logging data offers no information about the 3-D conductivity distribution in the vicinity of the well. The 3-D conductivity structure surrounding a borehole can only be characterized if multiple components of the magnetic fields due to various source polarizations are acquired. Recently EMI has developed the Geo-BILT system, which is composed of a three-component magnetic source and two three-component inductive receivers spaced at 2 and 5 meters, respectively, from the transmitter. This results in a 3x3 tensor data for each spacing due to the nine combinations of the transmitter and receiver orientations at a specific source depth for each spacing. However, 3-D interpretations using such single-hole EM data is difficult because of the richness and complexity of the data and the very large number of discretized conductivity elements needed to represent a realistic earth model. Taking advantage of the computing efficiency of the MEBA code, we modified the code for interpreting such data sets acquired in single-hole environment.

A set of single-hole EM data was collected with Geo-BILT at the Lost Hills oil field in southern California, USA. Field data were collected in a fiberglass observation well located 100 ft from a water injector used for pressure maintenance on the oil field. The Geo-BILT results agree with the traditional induction logging data in the near well environment but show substantial differences in the intervals where water injection are known to occur. The MEBA inversion provided a 3D image to a distance for 8m from the well and illustrates several zones where water injection has changed the fluid saturation in a 3D sense.

Session: Three-dimensional subsurface electromagnetic imaging and inversion.
Session organizer: Michael Zhdanov.
Presentation preferred: oral.

Abstract title for PIERS 2003:
Three-dimensional interpretation of electromagnetic data, a review and recent advancement at LBNL

Session: Three-dimensional subsurface electromagnetic imaging and inversion.
Session organizer: Michael Zhdanov.

Authors:

Hung-Wen Tseng (corresponding and presenting author)
Lawrence Berkeley National Laboratory
1 Cyclotron Rd., Mail Stop 90-1116
Berkeley, CA 94720
U.S.A.
Phone: (510)486-5502
FAX: (510)486-5686
E-mail: hwtseng@lbl.gov

Ki Ha Lee
Lawrence Berkeley National Laboratory
1 Cyclotron Rd., Mail Stop 90-1116
Berkeley, CA 94720
U.S.A.
Phone: (510)486-7468
FAX: (510)486-5686
E-mail: khlee@lbl.gov

Michael J. Wilt
Electromagnetic Instrument Inc.
1301 S. 46th St., UCRFS
Richmond, CA 94805
Phone: (510)232-7997
Fax: (510)232-7998
Email: mwilt@slb.com