

Introduction to Magnetotellurics (MT) with Examples
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Abstract

In 2001, SMRI nominated MT as an R&D topic, because of interest in using MT for surface-based, non-invasive mapping of underground salt dissolution caverns.

This paper provides a basic introduction to MT for those unfamiliar with the technique, gathering relevant material from many sources into a single reference.

The paper covers:

- history and conceptual background.
- measurement procedures.
- data processing and display procedures.
- basics of interpretation.
- brief examples of usage in various fields.
- advantages and limitations.
- commonly used terminology.
- bibliography of useful MT papers.

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MT—invented in France (Cagniard) and USSR (Tikhonov) in the 1950s—is a “passive” geophysical technique (no man-made energy source), which measures naturally-occurring electromagnetic (EM) field fluctuations. MT measures earth’s natural electric (“telluric”) and magnetic fields, hence the name.

The natural source comprises:

- (a) low frequency source (thousands of seconds period to a few Hz)
 - (b) high frequency source—from a few Hz to approx. 10 kHz.
- Source (a) is powerful globe-circling “ring currents” flowing in the ionosphere (analogous to the jet stream). Source (b) is worldwide lightning—approx. 100 strikes per second.

“MT” refers to frequencies below approx. 400 Hz, and “AMT” (audio frequency MT) to frequencies from approx. 1 Hz to 10 kHz.
A different technique using man-made signals is called CSAMT (Controlled-Source AMT).

MT measures electric and magnetic fields at the surface of the earth, across a wide range of frequencies, to provide information about the resistivity vs. depth structure. Depth of investigation is approx. proportional to square root of period.

Simple analog MT equipment was extensively used in the USSR in the 1950s and 1960s for hydrocarbon reconnaissance in vast areas of Siberia. The giant Urengoi gas field was discovered by MT.

The US oil industry has used MT since the late 1960s. MT usage increased in the 1970s because of oil price hikes, improving technology, decreasing cost, and a theoretical advance called “remote reference”(Gamble, 1978).

Technical advances in 1996 (“3D-MT”) reduced cost significantly, providing more, higher precision data, and improving interpretation. MT usage then significantly expanded in China (the biggest user).

MT is used worldwide in exploration for geothermal resources, hydrocarbons, deep metallic ore bodies, diamonds and groundwater; and for earthquake prediction research. Brief examples are provided.

CSAMT first mapped a deep brine pocket in 1984. MT was first used for deep (500 m to 2500 m) mining exploration in 1992. Mining targets are discrete, electrically conductive 3D bodies in electrically resistive host rocks—similar to brine-filled salt caverns. Some recent results were not predicted by theory.

Observation (data) presently appears somewhat ahead of theory and computer-aided modeling/inversion.