

Magnetoencephalography MEG



Fetal Magnetoencephalography MEG



Magnetocardiography MCG



Goal is to determined the 3-d current distribution during the cardiac cycle



magn. field 12.5-10[°]fT time 1 s

inverse problem has to be solved:

Vector-Magnetometer are used, and excitation propagation has to modeled "current dipoles" are introduced to describe magnetic field distribution data are combined with ECG data and MRI data



ws 22/23 Geophysical and Archeology Applications



- Rock magnetometry
- Transient electromagnetic measurements (TEM)
- Geomagnetic measurements: Tensor gradiometry
- Magnetotellurics (MT)
- Magnetic anomaly detection (MAD)
- Gravimetry
- Challenges
- Large distances to source
- Measurements in the open field
- Measurements with moving sensors
- Wide range surface mapping







Geomagnetic Measurements



Full Tensor Magnetic Gradiometer (FTMG)

$$\hat{B}_{ik} = \begin{pmatrix} \frac{\partial B_i}{\partial x_k} \end{pmatrix} = \begin{pmatrix} B_{xx} & B_{xy} & B_{xz} \\ B_{yx} & B_{yy} & B_{yz} \\ B_{zx} & B_{zy} & B_{zz} \end{pmatrix}$$
$$\hat{B}_{ik} = \begin{pmatrix} B_{xx} & B_{xy} & B_{xz} \\ B_{xy} & B_{yy} & B_{yz} \\ B_{xz} & B_{yz} & -B_{xx} - B_{yy} \end{pmatrix}$$

5 independent tensor elements

only 5 sensitive, linear independent gradiometers required to determine the full gradient tensor

Advantages of FTMG

- higher sensitivity for shallow structures
- sharper anomaly outlines
- enhanced information content
- insensitive to (homogeneous) regional trends and time-of-day variations

Simulation of cube ($\chi = 0.1$) in 20 m depth magnetic field: inclination – 62°, declination –16°





Example of locating an object with time-of-day variations : airborne detection of a truck



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- SQUID sensitivity is typically not the limiting factor
- for airborne gradiometer systems, noise cancellation is a critical technology
- in addition, compensation of motion-induced artifacts is often needed
- can also be applied to locate for landmines and unexploded ordinance





Typical airborne FTMG detection system



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Airborne FTMG detection system for mineral searches

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compensation of motion-induced artifacts



- -- without compensation
 - after compensation with additional magnetometers, accelerometers, laser gyroscopes

Geomagnetic Measurements



Survey in South Africa at 50 m height





Distance (m)

36705 143





Cannington silver and lead mine in Australia (largest silver mine on earth)

discovered by aerial magnetic survey in 1990



Archeological Surveys







Archeological Surveys



Niederzimmern Neolithic Double-ring Ditch Exploration

Early bronze age (~ 5500 BC)









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Principle idea

- current pulse in a large loop produce time-varying magnetic fields
- eddy currents are induced in conductive material
- secondary fields from these object are monitored
- decay time of signal indicates conductivity of material





Transient Electromagnetic Measurements (TEM)









TEM Setup in the field



Transient Electromagnetic Measurements (TEM)



artillery shell

0.6

8.0

1.0













Magnetotellurics (passive TEM)





Magnetotellurics (passive TEM)





Magnetotellurics (passive TEM)



Resistivity map of northern USA



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Krýsuvík (Island) high-temperature geothermal field

