MEASUREMENT OF ELECTRIC AND MAGNETIC FIELDS AND GRADIENTS IN THE CONDUCTIVE OCEANIC MEDIUM

DAVID CLARK

CSIRO Materials Science and Engineering, Lindfield, Australia,
email: David.Clark@csiro.au

Electric and magnetic fields within a conductive medium are perturbed by the measurement process. In particular, sensors located within or around an insulating measurement capsule measure fields that are modified by the diversion of conduction currents around the capsule. In air or free space the gradient tensor is symmetric, as well as traceless. In the presence of conduction currents the curl of **B** is non-zero and the gradient tensor is asymmetric. This raises the question of what is actually measured by magnetometers and gradiometers immersed in the electrically conductive ocean. In particular, how does the signal measured within a sealed capsule (within which the gradient tensor is symmetric) relate to the field components and the asymmetric gradient tensor that existed in the surrounding medium prior to insertion of the measurement package?

This paper presents theoretical relationships between measured electric and magnetic fields and gradients and the corresponding quantities that would exist in the unperturbed medium, for a variety of geometries, including ellipsoidal measurement capsules. For example, for a small spherical cavity within an initially uniform horizontal quasistatic electric current distribution, bounded above and below by horizontal surfaces, the electric field within the cavity is parallel to the unperturbed applied field and larger by 50%. The magnetic field at the centre of the cavity is equal to the unperturbed magnetic field that existed at the same point in the conductive medium, prior to insertion of the measurement capsule. The symmetric magnetic gradient tensor within the cavity is uniform. The only non-zero components are B_{yz} = B_{zy}. These components are each equal to half the value of B_{zy} that is produced by the unperturbed current flow in the conductive medium.

The response of an ellipsoidal cavity is anisotropic. The electric field and magnetic gradient are uniform within the cavity. Analytic expressions for the fields in and around an ellipsoidal capsule have been derived. Effects of nearby conductivity interfaces, such as the seafloor or sea surface, can be incorporated using the method of images. Implications for marine controlled source EM surveys, magnetotelluric measurements and magnetic gradient tensor surveys will be discussed.

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David Clark, CSIRO Materials Science and Engineering, PO Box 218, Lindfield, NSW 2070, Australia