

The bulk electrical conductivity of the rectangular prism model

Tsutomu Ogawa[1]; Makoto Uyeshima[1]

[1] ERI, Univ. Tokyo

Based on an assumption that the space is cyclically fulfilled with a unit rectangular prism which is divided by 3 planar cuts which are perpendicular to each other into 8 elementary rectangular prisms whose homogeneous electrical conductivities are different in general, the mathematical expression of the bulk electrical conductivity of the space (called as the rectangular prism model, RPM) is derived as a function of the geometry of the elementary rectangular prisms and 8 electrical conductivities. Assuming that the scale of the unit rectangular prism is smaller than the typical scale lengths which appear in the geoelectrical and geoelectromagnetic explorations, the electric field and the electric current density averaged over the unit rectangular prism are derived from the electrostatic potential field in the unit rectangular prism. The bulk electrical conductivity is determined with the condition that the summation over the unit rectangular prism of the Joule heat in each elementary rectangular prism by the averaged electric field and the electric current density is minimized. The bulk electrical conductivity matrix is diagonal and shows anisotropy in general. In case that each elementary rectangular prism is cubic and that 2 different elementary electrical conductivities are considered, the followings are shown. The film and tube models of the bulk electrical conductivity by Watanabe (2005) is asymptotes of RPM. The electrical conductivity of the modified brick-layer model (MBLM) by Schilling et al. (1997) exceeds that of RPM by several tens of percents in case that the volumes of each elementary cubes nearly equal. It is shown that the Joule heat per the unit cube of MBLM is larger than that of RPM.