Relationship between the average depth of a causative layer and the power spectrum of the vertical gradient component of a gravity gradient tensor

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In recent decades, six components of the gravity gradient tensor have been observed by gravity gradient exploration, and techniques for estimating the subsurface structure using these data have been studied and developed (e.g., Zhang et al., 2000; Beiki and Pedersen, 2010; Barnes and Barraud, 2012; Martinetz et al., 2013). In such research, filtering to extract the specified wavelength from the total gravity gradient tensors is not conducted frequently for subsurface estimations. One reason for this omission is that the wavelength characteristics differ among the components of the gravity gradient tensor. Filtering is an important data processing method for estimating subsurface structures. When this technique is applied, it is necessary to determine the relationships among the components of the gravity gradient tensor and subsurface structures. In the case of a gravity anomaly, the well-known relationship between the power spectrum and the average depth of the subsurface layer plays an important role in the filtering. Such relationships for the gravity gradient tensor have not been shown thus far. Therefore, we attempted to derive the relationship between the average depth of the causative subsurface layer and the power spectrum of the vertical gradient component of the gravity gradient tensor. Although the gravity gradient tensor has six components, we employed only the vertical gradient component because it has often been used for interpreting data and for estimating subsurface structures. We derived an equation for this relationship, which is shown to be nonlinear in the semi-logarithmic scale. We applied the equation obtained in this study to the vertical gradient component of the gravity gradient tensor observed in the Kuju geothermal area of central Kyushu, Japan, and we obtained results that are consistent with the average depth estimated by spectrum analysis of the gravity anomaly. However, we determined that the equation cannot estimate the average depth of the subsurface layer at the longest wavelength range. In addition, the wavenumber range giving the same average depth as that given by spectrum analysis of the gravity anomaly shifts to a higher and wider wavenumber range.
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