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Three-dimensional joint inversion of gravity and magnetic anomalies using fuzzy c-means clustering

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The gravity and magnetic surveys have been widely carried out over the years, especially for the exploration of metallic mineral deposits and geothermal resources. These field intensity data could be acquired in much quicker and simpler way than the other geophysical or geological data. The inversion of potential field data, however, has been known as a non-uniqueness problem expressed in the Green's equivalent layer theory. Because of this problem, gravity and magnetic data have no inherent resolution in depth. We, therefore, would like to develop a way to make use of high exploration efficiency that takes the advantages of the convenience to conduct gravity and magnetic surveys.

We present a 3D joint inversion method to estimate two physical parameters, density and magnetization of subsurface materials. In the method, we introduce the fuzzy c-means (FCM) clustering technique in our joint inversion algorithm to consider the petrophysical relation between density and magnetization of subsurface materials. The fuzzy c-means clustering technique we introduce does not necessitate any empirical equation but deals with a linear combination of the influence from multiple clusters given a piece of data to belong to plural clusters in the parameter space formed by the petrophysical parameters.

In this study, we focus on natural resources such as submarine massive sulphides (SMS), which are attractive material due to the recent rapid growth of global economical activities, but their deposit locations below deep seafloor restricts the access. This necessitates detailed exploration using potential field data. We test our inversion method using synthetic numerical experiments for SMS. The joint inversion results using gravity and magnetic data sets show higher accuracy and resolution than the individual ones, and especially have improved horizontal resolution. We conclude that our joint inversion method demonstrates the accuracy of our method in the estimation of SMS in terms of the gravity and magnetic anomalies.