Fault dip estimation based on gravity gradient tensor on a profile

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It is widely accepted that the area of a disaster occurrence is generally wider on the hanging wall side than on the foot wall side of a fault and that the fault dip affects the size of the disaster area. Therefore, fault dip is an important fault parameter and has played an important role in numerical simulations for the development of hazard maps. To determine or estimate the fault dip, morphological, geological, and geophysical surveys such as excavation, seismic reflection survey, gravity survey, and other research means have been employed worldwide and have yielded extensive knowledge on fault dip and shapes.

In recent years, gravity gradiometry surveys have been widely conducted to obtain detailed subsurface structure data. This type of survey collects the gravity gradient tensor defined by the second derivatives of the gravity potential. Compared with the gravity anomaly, its response to subsurface structures is more sensitive. Various analysis techniques using gravity gradient tensors such as inversion and the semi-automatic interpretation method have been employed and discussed. Among these methodologies, a technique for estimating the fault dip by using the gradient tensor has been developed. Although the technique has yielded excellent results, gravity gradiometry surveys have been conducted in only a few areas in Japan. Hence, analyses conducted in areas in which gravity gradiometry surveys have not been conducted require use of the tensor estimated from existing gravity anomaly data.

In this study, techniques for estimating the gravity gradient tensor from gravity anomalies are shown for a profile that is frequently employed in active fault research. Moreover, these methods are employed for estimating the fault dip by using eigenvectors of the observed or calculated gravity gradient tensor on the profile. As a result, the dip of the maximum eigenvector is shown to closely follow that of a normal fault, and the dip of the minimum eigenvector closely follows the dip of the reverse fault. As an application to field data, the dip of the Kurehayama Fault located in Toyama, Japan, was estimated. A fault dip of about 42° was obtained as the dip of the minimum eigenvector of the gravity gradient tensor because the fault is a reverse fault. This dip is in agreement with conventional geological information. Although the calculated gravity gradient tensor was employed here for estimating the fault dip, the technique shown in this study is applicable to the observed data for each profile directly obtained through gravity gradiometry surveys by helicopter.

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