Estimation of fault activity by multivariate analysis using chemical composition of fault gouge

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Introduction: Active faults are recognized by displacement / deformation of current topography and the Quaternary strata. However, in the absence of them, it is very difficult to decide whether the fault there is an active fault or not. In this study, we tried multivariate analysis using chemical composition data of fault gouge of active faults and inactive faults in Japan, and tried to determine the presence or absence of fault activity.

Methods: This research was carried out in the following order; collection of papers, extraction of chemical composition data of fault gouge, addition of new chemical analysis data, formatting of input data, variable selection, linear discriminant analysis. First, chemical composition data of fault gouge of active faults and inactive faults in Japan was extracted from existing publications. In this case, the extraction condition clearly describes whether the analysis target is an active fault or an inactive fault and that the basement rock is diverse. In addition, a chemical analysis of the fault gouge sample possessed by the JAEA was carried out, and we created a database that integrates both of them. In this database, in addition to the sample name and analytical value of each sample, 2 categories of active fault and inactive fault were given. Then, we decided elements to be candidates for explanatory variables from this database and arranged them as input data. Since the chemical elements extracted from the literature are not all analyzed for the same element, common elements are chosen so that the number of samples can be taken as much as possible. In order to further extract elements suitable for discrimination between active fault and inactive fault from these elements, variables were selected by two methods of Akaike Information Criterion (AIC: Akaike, 1973) and principal component analysis. Finally, linear discriminant analysis was performed using as an explanatory variable a combination of an element selected by AIC and an element whose factor loading amount was considered to be high in the principal component analysis.

Results: As a result of collection of papers, chemical composition data of fault gouge was extracted from 7 existing papers and 5 reports of the JAEA. We extracted 17 elements as candidates for variables from the database, to which a chemical analysis result of 6 fault gouge samples possessed by the JAEA was added. The number of data was 41 samples for active fault and 16 samples for inactive fault, totaling 57 samples. From these 17 elements, 13 elements were extracted as optimum combination of elements in AIC. In the principal component analysis, synthesis expressions from the first principal component to the 17th principal component were obtained, and elements with high factor loading amounts were calculated for each synthesis formula. From these results, linear discriminant analysis was carried out with a following combination of elements; (a) 13 elements of AIC, combination of elements whose average value of factor load amounts falls in the top 10 of (b) Up to the 3rd principal component of principal component analysis (explain the scattering degree of chemical composition by 65%), (c) Up to the 5th principal component (also 80%), (d) Up to the 8th principal component (also 90%). As a result, a combination of (a), (c) and (d) gives a primary equation that accurately divides the 2 groups of active fault and inactive fault.

Consideration: The elements common to the combination of the above are 6 elements of TiO_2, Al_2O_3, MgO, Na_2O, P_2O_5, Ba. Linear discriminant analysis was carried out again with (e) the combination of these 6 elements, and it resulted in accurate division of the 2 groups. Since these elements are selected by different methods or filters, there is a possibility of elements representing the difference between active faults and inactive faults. Also, as a result of assigning data of 3 specimens of fault gouge of another active fault to each primary equation, values which are judged to be active faults in all equations were obtained. However, these values were out of the distribution range of the population, and the tendency was more conspicuous as the number of elements was larger. From this, the primary equation consisting of 6 elements of (e) was considered to be the best formula to separate active fault and inactive fault.

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