The weathering resistivity of plutonic rocks interpreted from the features of microscopic void structure

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The void structures of weathered plutonic rocks were examined using quantitative methods such as multifractal analysis, pore size distribution and effective porosity measurement. And the values characterizing the void structures were correlated with uniaxial compressive strengths(UCS) to clarify the weathering resistivity of the plutonic rocks.

Samples are Inada granite and Kuroishiyama gabbro. Inada granite is biotite adamellite collected from Kasama, Ibaraki prefecture, Japan and dominantly constituting minerals are quartz, potassium feldspar, plagioclase, and biotite. Kuroishiyama gabbro is hornblende gabbro collected from Ono, Fukushima prefecture, Japan and composed mainly of amphibole, plagioclase, and chlorite.

The multifractal analysis characterizes the degree of the heterogeneity of the void structure. Analyzed image is tiled image which consists of 25 microphotographs taken with fluorescent method, and it is standardized as the totals of pixel values become similar among the tiled images. The images were analyzed with so-called box counting algorithm and generalized dimension spectra were obtained. Effective porosity and pore size distribution were measured using the method suggested by the Japanese Society of Soil Mechanics and Foundation Engineering and mercury porosimetry respectively. Uniaxial compressive strength test was carried out under constant strain rate(0.2mm/min.). Additionally, the texture observation of the samples was performed using microscope and film scanner.

A regression line showing the relationship between effective porosity and UCS of the granite has smaller intercept and larger slope than the gabbro. This means that the gabbro have larger UCS than the granite when they have similar effective porosities and that the UCS of the granite decreases more significantly than the gabbro when their effective porosities increase equally. Furthermore, q-Dq-UCS curved surfaces drawn from the relationship of generalized dimension spectrum and UCS show that the granite has steeper slope. It means that the UCS of the granite decreases more drastically than the gabbro when their degrees of heterogeneity increase similarly.

Inada granite has granular texture, and void structures occurred through weathering are inter-granular fractures, trans-granular fractures, and intra-granular fractures in quartz in addition to intra-granular fractures in plagioclase. Inter-granular fractures, trans-granular fractures, and intra-granular fractures in quartz are continuous and linear, and their fracture density is relatively small. That’s why the void structure of the granite largely contributes to the decrease in UCS but influence on the heterogeneity of the void structure is not so strong. On the one hand, Kuroishiyama gabbro is characterized by poikilitic texture, and remarkable intra-granular fractures in plagioclase are observed. Intra-granular fractures in plagioclase are densely distributed and contribute to the increase in the heterogeneity of the void structure. However, the skeleton of amphibole is not so affected by weathering and thus the strength of the gabbro is maintained.

Generally, granite is composed of minerals which have relatively high weathering resistivity such as quartz. The results, however, show that the UCS of the granite tend to decrease easily when the two plutonic rocks are compared based on their void structures. This may indicate that the gabbro has higher weathering resistivity than the granite. The weathering properties of the two plutonic rocks are considered to be consistent with geomorphological features observed in the field. It was indicated that the interpretation of weathering property from microscopic void structure quantification is possible.