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Analysis of fractal geometries of veins in the Sambagawa metamorphic rocks in the Nagatoro area, Saitama

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Fractal geometry analysis has been applied to many geological features for more than a decade. The fractal dimension is a scale invariant index representing the degree of self-similarity of a pattern. Scale invariant indices are known to be useful in predicting the frequency of earthquake occurrences, Logarithmic frequency distribution has been typically used for the frequency analysis of earthquakes. Earthquakes are, however, just the extremes of what occurs in the dynamically deforming earths surfaces. Brittle deformation of rocks (that did not always lead to earthquakes) leaves evidence in the rocks themselves as sealed cracks (veins) of various size. Investigation of rocks with sealed cracks by way of a scale invariant analysis may lead to the total understanding of the crack forming and brittle deformation of the rocks in the seismic condition. In this study, fractal geometry analysis was applied on the vein-rich schists from the Sanbagawa metamorphic belt exposed in the Nagatoro area, Saitama, Japan. Two dimensional analyses were carried out on the two dimensional spatial distribution of veins observed in sample outcrop surface areas.

The Sanbagawa belt is a high-pressure intermediate type regional metamorphic belt exposed in the south-westJapan. The Sanbagawa schists exposed in the Nagatoro area, Saitama, Japan, are known to have conspicuous veins. 5 outcrops of pelitic schists in the lowest grade zone (zone I) located along the Arakawa-river were selected for the fractal geometry analysis. A relatively flat surface with an area approximately 2 * 2 [m] was chosen as a sample area in each outcrop. Veins in each sample area were sketched and hand-traced using color photos. Two different approaches were taken. In one case, each vein was represented by a line (width 0) which was drawn in the center of each vein. In the other case, the vein was traced as it is (with width), Box counting method was applied to the sample areas and the fractal dimension of the 2D spatial distribution of veins on the sample area were estimated.

The obtained fractal dimensions were 1.3 to 1.7 for "width 0" samples, and 1.4 to 1.9 for "with width" samples. The analysis with width deduced slightly higher values in all localities. Outcrops which seemed (to the eye) to have relatively larger number of thick short veins produced smaller fractal dimension values. The mode of the vein width data did not exhibit such tendency. The fractal dimensions seemed to correlate with the appearance of the mass of veins more than the basic statistical value. Outcrops from lower metamorphic grade tended to yield higher fractal dimension values, however without significant difference. In addition to the metamorphic grade of the host rock, the mineral assemblage in the vein is the index of the deformation condition. The correlation between the fractal dimensions and the deformation conditions of the rocks will be discussed.

Keywords: metamorphic rock, Sanbagawa, vein, fluid, fractal