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Strain analysis of deformed spot structures in basic schists

Yukiko Yamasaki[1*], Takeshi Ikeda[1]

[1]Kyushu University

Strain analysis provides important information to estimate deformation history and the magnitude of strain of rocks. The initial and final shapes of the structure are necessary to employ it as strain marker. Especially in the case of metamorphic rocks, it is difficult to determine the initial shape of the structure whose origin is known. Strain analysis for these rocks assumes a hypothetical shape as an initial shape. For example, Toriumi and colleagues estimated strain using deformed radiolarian fossils in the Sanbagawa Metamorphic Belt (e.g. Toriumi 1982, 1990; Toriumi & Noda 1986). They assumed the initial shape of the fossils as sphere. However, the variation in initial shape of various fossil species can not be negligible when the magnitude of strain is very small (Shimizu, 1988). Shimizu (1998) employed alternative method that takes the variation of the initial shape into account in the low-grade part of the Sanbagawa Metamorphic Belt. Simplifying an initial shape of all species of the radiolarian fossils as a sphere prevents from the accurate strain analysis. It has been, so far, implausible to use the structures of which origin is not known as strain marker. This study estimated the initial shape of the deformed structure whose origin is unknown based on the internal microstructure, and then estimated quantitatively the magnitude of strain.

The deformed spot structures commonly occur in basic schist of the Sangun Metamorphic Belt along the coast at Nogita, northwest of the Itoshima Peninsula, northern Kyushu, Japan. They are uniaxially elongated to form a lineation within the schistosity plane. The structure consists of aggregates of plagioclase with various grain sizes. This study divided those structures into five types based on the maximum crystal size constituent of the structure. The types are referred to type1, 2, 3, 4 and 5 in the descending order of the crystal size. Some spots of types 1 and 2 consist of a coarse grain of plagioclase that is composed of subgrains. These subgrains represent similar crystallographic orientation and possess common straight twinning plane. The coarse grain can be regarded as a single crystal originally that did not undergo the significant deformation. Two thin sections were prepared: one is normal to the schistosity and parallel to the lineation, and the other is set normal to the both. The long and short axes of the spot were measured. Those obtained from the former section are defined as a1 and a3, respectively. The latter section provides a2 and a3, respectively. The maximum crystal size decreases with increasing the ratio of long axis and short axis. The angle between the orientations of the schistosity and long axis of the structure decreases as the ratio increases. All the types are plotted on a straight line representing plane strain in Flinn Diagram along with the plots tend to be isotropic with increasing the maximum crystal size.

The strain of the rocks includes not only shape change of the spot structures but also reduction of crystal size of constituent plagioclase by micro brecciation. Most structures classified to type1 are composed of single or several grains that did not deform, as judged from straight twinning plane. This suggests that the shape of type1 can be treated as the initial shape of the structures. The a1, a2 and a3 axes changed their length by a factor of 2.2, 1.0 and 0.44, respectively, to form type5. Alternatively, if the initial shape of the structures were assumed as sphere, type5 requires much longer change of a1, a2 and a3 axes (factor of 4.6, 0.94 and 0.24, respectively). Therefore, spherical assumption overestimates the magnitude of strain of the spot structures.

This study estimated the initial shape of the deformed structures whose origin is unknown. This

enables us to measure the magnitude of strain. The new point of view used in this study may increase the number of microstructure that can be applied to a strain marker.

Keywords: strain analysis, strain marker, initial shape, metamorphic rock, internal microstructure