Banding structure in metamorphic rocks

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Banding structure is a ubiquitous texture in metamorphic rocks formed by regional metamorphism, which is observed regardless of its protolith, metamorphic grade and region. It is very important to clarify the origin, because it may include information concerning kinetics of metamorphic reaction and initial condition of folding process (i.e., deformation process) which originates from banding structure. The origin has been frequently discussed since Eskola(1932), but remain largely controversial due to lack of detailed comparison between theory and natural analysis. The problem is the origin of anisotropy in structure and mechanism of differentiation. The followings are regarded as the major factors that may cause banding structure formation: (1) initial structure of its protolith, (2) mechanical effect (e.g., shear crack, flow differentiation), (3) chemical effect (e.g., coupling of diffusion and reaction).

In this study, we examine the origin of banding structure using basic rocks from Sambagawa belt in Shikoku, southwest Japan. Sampling points are distributed from central to western part of Shikoku, corresponding to high grade to low grade metamorphism.

In western part (i.e., lower grade), basic rocks are composed of albite-actinolite layer and epidote-actinolite layer with small amounts of pumpellyite-rich layer and chlorite-rich layer, which are characterized by unclear boundary and larger mean width (1cm). In central part (i.e., high grade), major minerals are hornblende, epidote and albite spot (or garnet). Banding structure is usually not developed so much, but albite spot (or garnet) is localized to be like layers in some rocks. In the area where rocks show intermediate grade, basic rocks are composed of albite-actinolite layer, epidote-chlorite layer and epidote-actinolite layer with small amounts of quartz layer, which are characterized by clear boundary and smaller mean width (1mm). Some outcrops in this area are considered to originate in pillow lava, initial structure of which is closely homogeneous, and these rocks show similar mineral assemblage and banding pattern to basic schists parallel to bedding plane. This indicates that the origin of banding structure is same in both occurrence. Therefore, banding structure can be formed during deformation and/or metamorphism.

As a result of XRF analysis, elements which are immobile to fluid system (e.g., Ti, V, Zr, Y, Nb) show a meaningful trend beyond the variation from heterogeneity, and many samples belong to non-alkaline basalts and tholeiitic series. Furthermore, discrimination diagrams for tectonic settings (e.g., Zr-Y-Nb, Ti-V, Ti-Fe/Mg) show that almost all samples originate in MORB, independent of its metamorphic grade and occurrence. This also supports that banding structure is formed during deformation and/or metamorphism, because of homogeneity in MORB texture.

Mineral compositions are measured by EPMA over the tens of centimeters in a direction perpendicular to layers to compute one-dimensional spatial profile for elements. Auto correlation function for each element behaves periodically and its amplitude damps gradually; the correlation length is roughly ten times as long as mean layer. Especially, function for mobile elements (e.g., Si, Na, K) show strong correlation. Furthermore, cross correlation function show weak correlation between different elements. These results mean that some mechanism to localize element distribution is needed during metamorphism and/or deformation.

We thus may conclude that initial structure of these rocks are homogeneous, and elements differentiate during metamorphism and/or deformation related to fluid. The mechanism to produce anisotropy may be related to rock flow because some samples have textures like lens, not like layer. The model which can explain these results is discussed, compared with existing models.