The relationship between the extent of retrograde reaction and the increment of strain of basic schists

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Overall metamorphic reaction in the basic schists proceeds continuously in the greenschists and epidote-amphibolite facies conditions. In such P-T range, Solid solutions change their compositions to keep the equilibrium conditions. Conspicuous growth zonings of minerals indicate that the reaction proceeded through dissolution and overgrowth processes. On the other hand, dissolution and overgrowth process of solid solutions is considered to be responsible for the deformation of basic schists, if a rock is under nonhydrostatic condition. The compositional zonings of amphiboles in the Sanbagawa schists commonly show the reaction history during the exhumation. In this study, the reaction progress and the strain increment of basic schists during late stage of amphibole growth are analyzed, and their relationships are investigated.

The basic schists were collected from the Besshi area in the central Shikoku. They are mainly composed of amphibole, epidote, chlorite, plagioclase and quartz. Amphiboles are commonly zoned from core to rim as bar-hbl-act in the albite-biotite zone and win-act in the chlorite zone. Thermodynamic analyses for the zonal profiles of matrix amphiboles provide us P-T paths during the exhumation. To evaluate the extent of the continuous retrograde reactions, amphibole grains are divided into two parts, core and mantle, by composition. The composition of core is usually hornblende in the albite-biotite zone and garnet zone, and winchite in the chlorite zone. The composition of mantle is actinolite. In this study, the reaction progress is defined as dMcore/M0core (change of the amount of amphibole core during actinolite-forming reaction / the amount of amphibole core before the reaction). To analyze the mass balance relation, bulk rock composition, mineral mode, mineral compositions, and Xact (the proportion of actinolite mantle part in the amphibole grain) were investigated. Xact was measured as the ratio of sums of areas using the chemical maps. Mass balance relation are formulated as the differential forms, and solved for modal changes of epidote, chlorite, plagioclase, quartz and. The results are as follows: (1) Hydration reaction proceeds in the albite-biotite zone and garnet zone, while the extent of hydration is rather small in the chlorite zone. This reflects the difference in the compositions of amphibole cores between higher-grade zones and chlorite zone. (2) The reaction progress (dMcore/M0core) relates to the measurement values of Xact, which implies that Xact is useful as the extent of actinolite-forming reaction for the albite-biotite and garnet zones.

The microboudin structures of amphiboles in the basic schists are useful for strain analyses. The neck of boudin is commonly filled by actinolite, which indicates that strain of basic schists was accumulated during late stage of exhumation. Strain analyses using Strain Reversal Method provide us the natural logarithmic strain with the range 0 - 1.0. The elongation of amphibole grains are composed of two components; separation of fragments and overgrowth outward. Except for the chlorite zones, above two components are closely associated with each other. Comparison the reaction progress with strain increments during the actinolite overgrowth revealed that strain magnitudes increase as the retrograde reaction proceeds.

The spatial distribution of Xact values in the Besshi area shows that the extent of actinolite-forming reaction in the basic schists is much higher in the garnet zone and in the lower part of the albite-biotite zone (the boundary zone with the garnet zone) than other parts. It is expected that the above narrow zone was strongly deformed relative to other part of the Sanbagawa belt during the late stage of the exhumation. The high strain zones corresponds to the bottom of the Besshi unit proposed by Wallis (1998).