Amphibole zonings in the Tanzawa metamorphic rocks -Estimation of the P-T paths by Gibbs' method-

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The Tanzawa Mountains is composed of a quartz diorite mass and surrounding low P/T type metamorphic rocks belonging to the zeolite facies to the amphibolite facies through the prehnite-pumpellyite facies and the greenschist facies. It is a fundamental question, whether the schists have suffered from the regional metamorphism, from the contact metamorphism, which heat provided by the intruded quartz diorite, or from the contact metamorphism which overprinted the former regional metamorphism. This study tries to estimate the quantitative P-T paths which the rocks experienced by Gibbs' method from compositions of zoned amphiboles.

Gibbs' method is the direct way to use thermodynamics to obtain quantitative continuous P-T paths from chemical composition of zoned minerals. The thermodynamic relationships are generally written with pressure (P), temperature (T) and chemical compositions of minerals (Xs). Gibbs' method deals with the differential forms of the equilibrium thermodynamic equations, for each reaction, and the stoichiometric equations, for each mineral. Therefore the variables are dT, dP, dXs. Substituting the small infinite changes of analytical compositions of a zoned mineral (dXs) as the independent variables into this system of thermodynamic equations, we get the rest dependent variables (dP, dT, dXs: other minerals). At this time, we need thermodynamic data sets of the mineral end-members and the appropriate activity models that relate the compositions of the minerals to its thermodynamic energies. Repeating this calculation enables us to obtain the P-T path which starts from the assumed initial conditions and compositional changes of other minerals.

Analyzed sample is a basaltic rock and it locates near the boundary between the greenschist zone and the amphibolite zone. The assemblage amphibole + epidote + chlorite + plagioclase + quartz + fluid (H_2O) in the system SiO_2 - Al_2O_3 - Fe_2O_3 - MgO - FeO - CaO - Na_2O - H_2O (8 components 6 phases' system: 4 degree of freedom). The amphibole grains are often zoned as actinolite - magnesiohornblende - tschermakite from the core to the rim. Chemical composition of sodic, calcic amphibole is described by 5 independent phase compositions, which can compensate the degree of freedom (4) of our system. That is, we can get uniquely the small changes of pressure, temperature and compositions of other minerals from the small changes of the compositions of the zoned amphibole. For the initial conditions, we assume 500C and 4kb, the maximum temperature and pressure of the greenschist and amphibolite boundary, and composition of the rim. We use mainly Holland and Powell (1998) for the thermodynamic data sets. Regular solutions model suggested by Powell and Holland (1993) and Margules parameters optimized to amphibole in the Sambagawa metamorphic belt by Okamoto (2002).

The prograde P-T path, which both temperature and pressure simply increases from core to rim, is obtained as a result of calculations. The dT/dP corresponding to the actinolite part is about 100C/km, and that to the magnediohornblende and tschermakite part is about 10C/km.

In the lower T conditions, the mineral assemblage differs from that of greenschist. This fact may be crucial problem which causes to miscalculate in the part corresponding to actinolite. On the other hand, the composition of amphibole in the Sambagawa belt is quite different from that in the Tanzawa. This calculated P-T path is not precise, but the steep dP/dT curve support that the greenschist had not been suffered from the contact metamorphism.

Basing on above discussion, we will estimate the quantitative P-T paths more accurately by using the suitable activity model and processing the large data.