東南極リュツォ・ホルム岩体の精密な温度圧力構造解明に向けて
−地質圧力計による圧力差の誤差の再検討−

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Toward precise determination of thermobaric structure of the Lützow-Holm Complex, East Antarctica : Re-examination of uncertainty in pressure difference of geobarometry

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The Lützow-Holm Complex (LHC), East Antarctica, shows a southwest-ward increase in metamorphic grade from amphiolite facies to granulite facies. Thermobaric structure of the LHC provides important information on the location and scale of heat source of metamorphism and crustal deformation during collision of west and east Gondwana. The metamorphic conditions of each exposure have been estimated based on several methos that include geothermobarometry, petrogenetic grid and pseudosectioning (e.g., Iwamura et al., 2013; Kawakami et al., 2008). Different methos have provided different metamorphic conditions, which may be ascribed in part either to inconsistency in basic thermodynamic properties or to preservation of different stages during the pressure-temperature path. Nevertheless, employing the same method such as single pair of geothermobarometers for different exposures enables to compare the metamorphic conditions in the complex at which the reactions used as the geothermobarometers ceased to proceed.

In general, geobarometers contain uncertainty that exceeds 100 MPa. The uncertainty of 100 MPa corresponds to the uncertainty in crustal depth of about 3.6 km. These features have caused difficulty in deciphering precise thermobaric structures (isobaric lines) in the complex. On the other hand, pressure difference between the distant exposures is also valuable to estimate an apparent pressure gradient. This study formulates the uncertaities in pressure and pressure difference of conventional geobarometers, and reveals that the pressure difference contains uncertainty smaller, in one order of magnitude, than that of the absolute pressure. We will reveal the precise thermobaric structure of the complex based on the same geothermobarometers. The uncertainties of thermodynamic properties such as enthalpy, entropy, and volume propagate to the uncertainty in pressure as,

$$\sigma_P^2 = \left(\frac{1}{\Delta V}\sigma_{\Delta H}\right)^2 + \left(\frac{T}{\Delta V}\sigma_{\Delta S}\right)^2 + \left(\frac{P}{\Delta V}\sigma_{\Delta V}\right)^2 .$$

In contrast, Ikeda et al. (2017) express the uncertainty in pressure difference as,

$$\sigma_{P_2-P_1}^2 = \left(\frac{T_2 - T_1}{\Delta V}\sigma_{\Delta S}\right)^2 + \left(\frac{P_2 - P_1}{\Delta V}\sigma_{\Delta V}\right)^2 .$$

The latter is devoid of enthalpy term, which reduces the uncertainty. In addition, $\sigma_{\Delta S}$, and $\sigma_{\Delta V}$ are multiplied by temperature- and pressure-differences, respectively, that are much smaller than absolute temperature and pressure.

Applying this formulation to several conventional geobarometers shows that the uncertainty in pressure difference is smaller than that in pressure estimation by a factor of at least one third, and that we are able to recognize 2 km difference in crustal thickness within the LHC.

References

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