

Microstructures and pressure-temperature condition in pelitic gneisses from the Lützow-Holm Complex at Akarui Point, East Antarctica

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Metamorphic rocks have been considered to preserve the mineral assemblage and composition at the peak condition in each pressure (P) –temperature (T) path. If this assumption is valid, the metamorphic rocks in the same outcrop are expected to show the same P - T condition. However, different P - T conditions have been estimated based on different geothermobarometers for rocks even from the same outcrop. Systematic difference among the methods could be responsible for these differences. However, this study revealed that use of the same pair of geothermobarometers provides significantly different P - T conditions for two pelitic gneisses from the same outcrop of the Lützow-Holm Complex, at Akarui Point, East Antarctica. An alternative interpretation is proposed to account for this difference.

The mineral assemblages of the studied gneisses are garnet, biotite, plagioclase, K-feldspar, quartz with and without sillimanite. Garnet grains in the Sil-bg. sample show round shape and contain large amount of fine quartz inclusions, whereas those in the Sil-free sample represent irregular shape and sporadically include coarse-grained plagioclase.

Garnet in both samples have chemically heterogeneity such that X_{Ca} ($=Ca/Fe+Mg+Ca+Mn$) and Mg/Fe decrease from the core to the rim. Furthermore, garnet in contact with biotite represents lower Mg/Fe than that in contact with other minerals. Garnet in the Sil-bg. sample is low in X_{Ca} and Mg/Fe as compared with garnet in the Sil-free sample. Phosphorus in garnet of the Sil-bg. sample represents euhedral shape of chemical contour in contrast to the garnet in the Sil-free sample where phosphorus shows no zoning. Biotite in the Sil-bg. sample shows Al-rich and low Mg/Fe as compared with that in the Sil-free sample. No systematic difference in Ti content in biotite is recognized. The Sil-free sample contains plagioclase with higher anorthite content than the Sil-bg. sample.

In the AFM approximation, garnet and biotite coexisting with sillimanite are expected to show higher Mg/Fe than those free from sillimanite. However, the present observations disagree with the prediction. Garnet contains significant amount of Ca, requiring addition of CaO to the chemical system. A calculated garnet composition diagram with respect to Ca-Mg-Fe shows that garnet coexisting with sillimanite represents a univariant line lower Ca and Mg/Fe than that free from sillimanite, and the present data are consistent with it. This suggests that two samples were not necessarily equilibrated at different P - T condition.

Geothermobarometry, in contrast, indicates significant difference in P - T condition. That is, garnet-biotite geothermometer (Ferry and Spear., 1978) and garnet-biotite-plagioclase-quartz geobarometer (Hoisch., 1990) show 685-718 °C at 6.4-6.6 kbar for the Sil-free sample and 828-855 °C at 7.2-7.8 kbar for the Sil-bg. sample.

It is puzzling feature that different samples from the same outcrop provide different P - T estimations using

the same geothermobarometers. The Sil-bg. sample records higher temperature than the Sil-free sample, as described before. Preservation of euhedral chemical contour of phosphorus in the Sil-bg. sample would indicate that the garnet grew maintaining surface equilibrium, at high temperatures. In contrast, absence of such euhedral contour and highly-rough surface of garnet in the Sil-free sample suggest relatively high growth rate, at low temperatures.

The P - T path of Akarui Point contains pressure decrease during temperature decrease (Iwamura et al., 2013). Considering this P - T path, it is expected that the garnet of Sil-free sample didn't exist at high temperatures and formed at low pressures and temperatures. The difference in estimated P - T conditions in the same outcrop can be attributed to not only the difference in the method but also the difference in the timing of the formation of minerals.

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