太古代の沈み込み地温勾配：南アフリカ、バーバートン緑色岩帯南方の花崗岩-緑色岩地域の変成作用

Subduction geotherm of mid-Archean collision zone: metamorphism of the granitoid-greenstone region south of the Barberton greenstone belt, South Africa

*青木 一勝[1]、山本 伸次[2]、小宮 剛[3]
*Kazumasa Aoki[1], Shinji Yamamoto[2], Tsuyoshi Komiya[3]

1.岡山理科大学　理学部　基礎理学科、2.横浜国立大学　環境情報研究院 自然環境と情報部門、3.東京大学　総合文化研究科　広域科学専攻
1.Department of Applied Science Okayama University of Science, 2.Graduate School of Environment and Information Sciences, Yokohama National University, 3.Department of Earth and Astronomy, The University of Tokyo

The approximately 3.5-3.2 Ga Barberton greenstone belt surrounded by TTG plutons and gneiss is one of the oldest and best-preserved examples of Archean geology in the world. Over the past fifteen years, migmatitic amphibolites, amphibolite and eclogite facies metamorphic rocks associated with ca. 3.23 Ga collisional event were reported from the granitoid-greenstone domain to the south of the Barberton greenstone belt (Dziggel et al., 2002; Moyen et al., 2006, Nédélec et al., 2012). Although it was pointed out that these rocks formed under geothermal gradients of ca. 12-20°C/km, which is similar to those found in recent subduction zone, the specific subduction geotherm at the peak-P metamorphism has not yet been clarified. In this study, in order to constrain the subduction geotherm at the time, we have examined the metamorphic P-T conditions of the highest-grade rocks in the granitoid-greenstone region near Badplaas by focusing on the petrology and thermodynamics of quartz-rich layers in metamorphosed Banded Iron Formations (sample no. BF152 and 153) at the Inyoni shear zone.

The studied samples contain the minerals quartz, garnet, grunerite, hornblende, hematite and epidote. Garnet porphyroblasts are commonly round shape and almandine-rich components. They are divided into two types based on the chemical analyses. The first-type has a chemical zoning. These grains are generally characterized by a decrease of Mn from core (GRT1: XSps = 0.06-0.08) to mantle (GRT2: 0.04-0.07), and an increase of that from mantle to rim (GRT3: 0.1-0.2). On the other hand, the Ca contents slightly increase from core (GRT1: Xgrs = 0.20) to mantle (GRT2: 0.22-0.24), and then slightly decrease to rim (GRT3: 0.20-0.21). The second-type shows no-chemical zoning. Chemical compositions of the type are quite similar to those of GRT2 or GRT3. Hornblendes (HBL1) show a nematoblastic texture and the chemical compositions plot in the ferrohornblende field. Some grains are overgrown by actinolite with increasing Si contents (pfu) (HBL2). Grunerites (GRU1) occur as anhedral grains and have Mn (pfu) values of 0.27-0.89. Some grains (GRU2) are slightly zoned from core to rim. The cores have Mn (pfu) values of 0.52–0.55 decreasing to 0.27-0.30 at the contact with retrograde actinolite. Epidotes occur as anhedal grains and the XFe3+ (= Fe3+/Al+Fe3+) ranges from 0.20 to 0.22. Hematite grains are ahnedral. The petrography and mineral compositions of studied samples indicate that peak mineral assemblage was GRT2 + HBL1 + GRU1 + Qtz + Hem and changed to GRT3 + HBL2 + GRU2 + Act + Qtz + Hem at a late stage.

The metamorphic P-T conditions were estimated by garnet-hornblende geothermometer (Graham & Powell, 1984 and Perchuk et al., 1985) using the program THERMOBAROMETRY ver. 2.1 (Spear & Kohn, 1999) and the average P calculations of THERMOCALC ver. 3.3.3 with the computer program AX (Holland and Powell, 1998 and its update). These results show that the investigated rocks underwent eclogite facies metamorphism at P= ca. 11-15 kbar and T = ca. 680-710 °C, and subsequently they underwent greenschist facies metamorphism at P= ca. 5-10 kbar and T = ca. 450-470 °C during exhumation. The

estimated peak P-T conditions correspond to previous works for the highest-grade rocks in the same area (Moyen et al., 2006).

Integration of our new results with published data suggests that the subduction geotherm at the peak-P metamorphism associated with 3.23 Ga collisional event was ca. 20-30°C/km and the trajectory was an anticlockwise with kinkpoint at around 10 kbar. This gradient gives close agreement with those of other collision-type HP-UHP metamorphic belts such as Himalaya and Kokchetav Massif. These features suggest the possibility that the mid-Archean crust was sufficiently cool and rigid, and some of the crustal materials were subducted to at least eclogite facies depths without melting during the continent evolution of the early Earth.