Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG06-04 会場:301A 時間:5 月 25 日 14:30-14:45

The stability of sapphirine + quartz in high/low oxygen fugacity rocks: a case study of Southern India/East Antarctica

The stability of sapphirine + quartz in high/low oxygen fugacity rocks: a case study of Southern India/East Antarctica

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Sapphirine has been the focus of many petrological investigations for the last two decades as the mineral often occurs in Mg-Al rich and pelitic rocks formed at high temperature to ultrahigh temperature (UHT). Particularly, sapphirine coexisting with quartz is considered as one of the most diagnostic mineral assemblages of UHT metamorphism. It is also known that sapphirine often occurs in magnetite-bearing high oxygen fugacity rocks, and, in such cases, the mineral can incorporate considerable quantity of ferric iron as well as Fe^{2+}. It is therefore important to evaluate the effect of Fe^{3+} content on the stability of sapphirine-bearing assemblages for estimating peak conditions as well as constructing *P-T* paths. In this study, we compared the stability of sapphirine + quartz in magnetite-bearing high-oxygen fugacity rocks from India (Madurai Block in the southern granulite terrane) with that in magnetite-absent low-oxygen fugacity rocks from Antarctica (Bunt Island in the Napier Complex) using mineral equilibrium modeling technique. The calculations have been done in NCKFMASHTO system using THERMOCALC 3.33 with an updated version of the internally consistent data set.

The Madurai Block is the largest granulite block in the Southern Granulite Terrane, India, which was formed by collisional orogeny related to the assembly of the Gondwana Supercontinent. The block contains granulites with various UHT mineral assemblages including sapphirine + quartz, orthopyroxene + sillimanite + quartz, and Al-rich orthopyroxene. Magnetite-bearing quartzo-feldspathic garnet-sillimanite granulites from Rajapalaiyam area in the southern part of the block, for example, contain sapphirine + quartz inclusion in garnet as a stable mineral assemblage at the peak of metamorphism. The calculated *T-X* pseudosections suggest that the stability temperature of sapphirine + quartz is lowered from 1000^{o}C at reduced condition (X_{Fe2O3} = 0.02) to 910^{o}C at oxidized condition (X_{Fe2O3} = 1.0).

The Napier Complex of Enderby Land, East Antarctica, underwent regional UHT metamorphism at ca. 2.5 Ga. Bunt Island in the Napier Complex, located in the highest-grade region of the complex, contains various kinds of UHT granulites including sapphirine-bearing rocks. Sapphirine + quartz assemblage, probably formed at the peak UHT condition, occur in sapphirine- and osumilite-bearing layers of the granulite. The absence of magnetite in the rocks indicates the sapphirine granulite was formed at reduced condition. *T-X* pseudosection of the rock suggests that the stability field of sapphirine + quartz is T $>$ 1050^{o}C at X_{Fe2O3} = 0.04, while it will be lowered in more oxidized condition (T $>$ 800^{o}C at X_{Fe2O3} = 0.24).

The results of this study demonstrated that the occurrence of sapphirine + quartz in UHT rocks is highly controlled by the oxidation state of the host rocks, particularly low oxygen fugacity rock is especially strongly influenced. In the case of Bunt Island, if X_{Fe2O3} increases by 0.04, the stability temperature of sapphirine + quartz will be lowered by 50^{o}C. It is therefore important to evaluate the effect of Fe^{3+} content of the stability of sapphirine-bearing granulites for estimating peak conditions as well as constructing *P-T* paths even if granulites were formed at reduced condition.

キーワード: サフィリン+石英共生, 南インド, 東南極, シュードセクション, THERMOCALC, 酸素フガシティー
Keywords: sapphirine + quartz, Southern India, East Antarctica, pseudosection, THERMOCALC, oxygen fugacity