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Metamorphic evolution of garnet-sillimanite gneiss from Ambatofotsy region, Antananarivo domain, east-central Madagascar

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Madagascar is situated within the central part of the Neoproterozoic East African Orogen (EAAO: Jacobs and Thomas, 2004) that marks the join between East and West Gondwana. Therefore, Madagascar is one of the most significant areas to understand the process of Orogen formation. In this study we report the newly found inclusion of kyanite + staurolite + muscovite + rutile in garnet and the mode of occurrence and discuss the metamorphic evolution of the garnet-sillimanite on the basis of estimated results by using various geothermobarometers and phase equilibrium by constructing psuedosection.

The Antananarivo domain is mainly composed of the felsic metamorphic rocks with subordinate amounts of the metasedimentary rocks (Tucker et al., 2012). There exposed magnetite-orthopyroxene-quartz gneiss (metamorphosed banded iron formation), garnet-orthopyroxene rock and garnet-hornblende-biotite gneiss around the garnet-sillimanite gneiss in the eastern part of the domain. The garnet-sillimanite gneiss is mainly composed of garnet, sillimanite, k-feldspar, plagioclase, and quartz with subordinate amounts of biotite, muscovite, monazite, zircon, rutile and graphite. Sillimanite is present in the matrix and as inclusion in garnet. Kyanite is only present as inclusion in garnet. Garnet (X_{Mg}=0.17-0.18) also contains spinel and abundant quartz and monazite inclusions. Spinel shows Mg poor (X_{Mg}=0.21-0.22) and Zn rich (ZnO = 18.4-19.0 wt.%) compositions. We newly found kyanite + staurolite + muscovite + rutile in the garnet. This staurolite shows Mg poor (X_{Mg}=0.12) and Zn rich (ZnO=3.1 wt.%) composition. Garnet is replaced rim of grain by radial aggregate of biotite (X_{Mg}=0.58) + sillimanite.

As a result of the petrographic observation, the metamorphic condition of the garnet-sillimanite gneiss was increased from the stability field from staurolite + quartz to garnet + kyanite (Spear and Cheney, 1989). Garnet + sillimanite + spinel + quartz was stable during the peak metamorphic condition. The estimated peak pressure and temperature condition is ca. 800 ℃ at 0.9 GPa by using garnet-sillimanite-plagioclase-quartz geobarometer (Spear, 1993) and garnet-sillimanite-spinel-quartz geothermobarometer (Nichols et al., 1982) with garnet activities calculated after Berman (1990). Garnet is replaced rim of grain by radial aggregate of biotite (X_{Mg} = 0.58) with sillimanite. This reaction is hydrous reaction from garnet + k-feldspar + H_2O to biotite + sillimanite + quartz with decreasing temperature (Le Breton and Thompson, 1988). This retrograde metamorphic condition is almost consistent with the estimated P-T condition from the garnet-hornblende-biotite gneiss. The estimated pressure and temperature condition is ca. 700 ℃ at 0.6 GPa by using garnet-hornblende geothermometer (Graham and Powell, 1984), hornblende-plagioclase geothermometer (Holland and Blundy, 1994) and garnet-hornblende-plagioclase-quartz geobarometer (Kohn and Spear, 1990). In summary we newly identified the clockwise P-T path from the garnet-sillimanite gneiss exposed in Ambatofoty region, eastern part of the Antananarivo domain.

Keywords: Gondwana supercontinent, east-central Madagascar, Antananarivo domain, Garnet-sillimanite gneiss, Clockwise P-T path