

## Ultrahigh-temperature metamorphism recorded in metamorphosed bauxite from the Red River shear zone, northern Vietnam

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Corundum + quartz +/- garnet association was found from the Red River shear zone, northern Vietnam. The granulite is rich in Al, Fe, Ti, HFSE and REE as well as poor in the other major elements and LILE, showing lateritic bauxite composition.

The granulite contains lots of garnet, corundum, sillimanite, spinel and ilmenite with minor amount of quartz, zircon, monazite and apatite. The garnet + corundum + quartz association is observed in the matrix as granoblastic materials. Sillimanite was not found between the corundum and quartz, and the quartz occurs in direct contact with corundum and garnet. Garnet includes kyanite, staurolite, rutile, siderite, corundum and quartz, whereas former four minerals are not observed in the matrix. The kyanite, staurolite and quartz inclusions are also observed in corundum. Ilmenite in the matrix includes garnet, corundum and sillimanite. Garnet and corundum are also present in sillimanite. The Fe-Mg solid solutions in minerals show nearly pure Fe end-members ( $X_{Mg}$  values in all ferromagnesian minerals are less than 0.1).

These petrographic observations seem to suggest the assemblage of garnet + corundum + quartz is in equilibrium. If it is correct, FeO-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub> petrogenetic grid suggested by Show and Arima (1998) can be applied, which allows the association is formed at higher than 1000 C and 1.1 GPa. We also estimated *PT* condition using *PT* isochemical phase diagram with the system CaO-FeO-MgO-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub>-H<sub>2</sub>O-CO<sub>2</sub>. The result shows that quartz appears only at very high-*T* (higher than 900 C) at low-*P* (less than 1.2 GPa) and is not in equilibrium with garnet, corundum and staurolite. In the phase diagram, rutile + siderite is key association for estimating *PT* conditions, which shows that peak-*P* condition is higher than 2.0 GPa at 800 C. Sillimanite included in ilmenite requires presence of sillimanite (not kyanite) during ilmenite growth, which implies *T* is as high as 1000 C at 1.5 GPa during decompression. Above results are strong evidence of UHT metamorphism in both cases (quartz is in equilibrium with corundum or not).