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Formation of garnet + corundum during isobaric cooling at UHT conditions: an example from pelitic granulites of the Highland Complex, Sri Lanka

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Coexisting garnet and corundum have been reported from different rock types such as UHP rocks, aluminous eclogites, kimberlites and numerous granulites worldwide which experienced UHT conditions of 900-1050 °C at relatively high but not eclogitic pressures of 10-12 kbar. In pelitic granulites the assemblage garnet + corundum is usually interpreted to form at peak P during prograde heating along a clock-wise metamorphic path and subsequently breaks down during decompression to form sapphirine, cordierite-sapphirine-spinel or spinel-sillimanite bearing assemblages, depending on the PT-trajectory and bulk rock composition. In any cases, coexisting garnet + corundum are rarely preserved. Even less usual is the occurrence of garnet + corundum in pyroxene-free rocks.

In this study, we report the occurrence of coexisting garnet + corundum within spinel- and corundum-bearing, orthopyroxene-free garnet-sillimanite-biotite-graphite gneisses from the Highland Complex (HC), Sri Lanka. In the investigated pelitic granulites, quartz-saturated domains and quartz-deficient domains are distinguishable. Quartz-saturated domains consist of quartz, plagioclase, alkali-feldspar, garnet-porphyroblasts and biotite flakes around garnet. Quartz-deficient domains are constituted of sillimanite, plagioclase, alkali-feldspar, corundum, spinel, biotite and two generations of garnet. Grt1 is coarse- to medium-grained (0.5-3 cm in diameter) and encloses rare Ti-rich biotite and numerous rutile needles and apatite rods. Grt2 is medium- to fine-grained (0.25-1 cm in diameter), contains rare sillimanite and/or spinel inclusions and is always associated with corundum. Corundum occurs in mutual contact with Grt2, partially embedded within rim area of Grt2 or as inclusions in Grt2. Rarely, tiny spinel inclusions can be observed in corundum.

The chemistry of minerals preserved as inclusion in Grt1 indicates that pelitic granulites attained maximal P of 10.5-11 kbar at T around 850°C during their prograde history. Further heating induced a series of biotite-melting reactions which progressively consumed biotite and quartz from the rock matrix and produced garnet-porphyroblasts and spinel. Textural observations coupled with both pseudosections calculated in the CNKFMASHTMnO system and Ti-in-garnet geothermobarometry suggest that peak metamorphic temperature occurred at UHT conditions of 950-975 0C and pressures of 9-9.5 kbar. Peak T was followed by a period of isobaric cooling responsible for the formation of corundum and Grt2 via the reaction Spl + Sil = Grt2 + Crn at around 930 °C, as well as exsolution of rutile needles and apatite rods from Grt1. Modelling of the mode of spinel, sillimanite, corundum and garnet confirms that along an isobaric cooling path at about 920-930 °C and 9-9.5 kbar corundum appears and spinel contemporaneously disappears. At the same PT conditions, our model predicts a decrease of sillimanite and an increase of garnet content. Further isobaric cooling produced a second generation of biotite at the rim of large Grt1-porphyroblasts at ca. 800 °C.

Therefore, the investigated granulites provide a rare but meaningful example where garnet + corundum formed along a retrograde metamorphic trajectory under UHT conditions, forcing to consider isobaric cooling at the base of the crust as an alternative process to explain the formation of coexisting garnet + corundum, especially if the studied rock lacks of cordierite or orthopyroxene.