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Petrology of sapphirine-quartz-bearing Grt-Opx-Sil-Qz migmatites from the Madurai Block (Southern Granulite Terrain, India): Evidence for a uniform P-T evolution for all sapphirine-bearing granulites from the Madurai Block during Gondwana assembly

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The Southern Granulite Terrain of India is well known for the widespread occurrence of ultrahigh temperature (UHT) granulite facies rocks. UHT conditions are mainly documented for MgAl-rich sapphirine-bearing granulites, which are reported from four localities in the Madurai Block, the major crustal domain of the Southern Granulite Terrain. However, different P-T conditions and P-T paths are reported for these occurrences (e.g. Tsunogae & Santosh, 2010; Brandt et al., 2011) including a clockwise evolution (localities Palni Hills, Usilampatti) and composite paths with initial post-peak cooling followed by decompression (localities Ganguvarpatti, Rajapalaiyam). In addition, the timing of UHT metamorphism (late Neoproterozoic in Palni Hills and early Neoproterozoic in Rajapalaiyam) is controversial (Braun & Appel, 2006; Brandt et al., 2011).

We present new petrological data from the little studied occurrence of sapphirine-bearing migmatites from Usilampatti (central Madurai Block), which suggest a common P-T evolution for all four sapphirine-granulite localities of the Madurai Block, in contradiction to the P-T reconstructions in previous studies. We have recognized sapphirine-quartz and orthopyroxene-sillimanite assemblages in the sapphirine-bearing migmatites of Usilampatti, which indicate significantly higher P-T conditions (ca. 1020˚C, 9 kbar) than previously reported (ca. 850˚C, 8 kbar, Subba Rao et al., 1997). Two types of sapphirine-bearing migmatites are distinguished: 1. Grt-Opx-Sil-Qz migmatite (bulk rock X_{Mg}: 0.70-0.72) and 2. Grt-Opx-Qz migmatite (bulk rock X_{Mg}: 0.67-0.63). By integrating constraints from P-T pseudosections with mineral chemical data and thermobarometric calculations we have reconstructed a clockwise P-T evolution for the rocks. The peak-assemblages Grt-Opx-Sil-Akfs-Rt-Qz and Grt-Opx-Akfs-Rt-Qz formed through progress of biotite dehydration-melting reactions during heating up to UHT conditions. The peak-assemblage Grt-Opx-Sil-Akfs-Rt-Qz is stable in a narrow P-T field between 8.0-9.5 kbar, and Grt-Opx thermometry as well as the high Al_20_3 content of porphyroblastic orthopyroxene (up to 10.4 wt%) document peak-temperatures of ca. 1020˚C. Sapphirine-quartz intergrowths, which occur in garnet and probably replace former sillimanite inclusions, and orthopyroxene-sillimanite intergrowths that replace garnet along grain margins record initial post-peak decompression of about 2 kbar at still UHT conditions. Sapphirine also occurs in sapphirine-cordierite symplectites replacing orthopyroxene-sillimanite and in sapphirine-orthopyroxene-cordierite symplectites replacing garnet. UHT decompression is consistent with the high Al content of orthopyroxene in the various reaction textures (9.5-8.0 wt% Al_20_3). Back-reactions with crystallizing melt led to the re-growth of biotite during post-decompressional cooling.

The mineral assemblages and reaction textures observed in the sapphirine-bearing migmatites from Usilampatti are remarkably similar to those of the Ganguvarpatti and Rajapalaiyam localities, suggesting a similar clockwise evolution also for the latter localities. The clockwise P-T path indicates that UHT metamorphism in the Madurai Block is related to collisional tectonics, probably active during the final assembly of the Gondwana supercontinent in the late Neoproterozoic.

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