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Tectono-metamorphic evolution of a hot orogen during Gondwanaland assembly: a case study from Palni hills metapelite granulite, south India

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This study deals with the tectono-metamorphic evolution of Sapphirine-cordierite-bearing metapelite granulite at Perumalmalai, south India, that occurs as enclave within deformed migmatitic enderbite gneiss of Kodaikanal massif, Madurai granulite block (MB), south India.

Pre-peak mineral paragenesis is represented by an inclusion assemblage of sillimanite + plagioclase + Ti-rich biotite ±quartz in Al-rich orthopyroxene. Dehydration melting of biotite marked the onset of ultra-high temperature metamorphism (M1A, ∼1000 ºC, 10 Kbar). Early stage of retrograde metamorphism (M1B) is characterized by the development of type1-symplectite and corona textures. In type1-symplectite an innermost vermicular sapphirine (Spr - XMg: 0.90, Al/Si: 6.17) - cordierite (Crd) symplectite on sillimanite is followed by cordierite (XMg: 0.94) moat. A meso-perthitic layer laced the interface between cordierite moat and orthopyroxene porphyroblast, the latter showing prominent rim-ward decrease in $Al2O_3$ (up to 3 wt%). The cordierite rim at the interface between sillimanite and orthopyroxene characterizes corona texture. Type1-symplectite and corona domains are circumnavigated by Ti-poor biotite (TiO_2: ∼3.2 wt%) showing shape preferred alignment, and set in a feldspar matrix showing wide compositional range. By implication, leucosome crystallization was possibly prolonged and enhanced by deformation. Type1-symplectite and corona textures were resulted from melt-solid interaction or silica-metasomatism during early stage of retrogression, Opx+Sil = Spr+Crd → Opx+Sil+melt = Crd. The retrograde metamorphism is constrained at 9 kbar and 950ºC, implying an early stage of near-isothermal decompression. Late stage retrograde metamorphism (M2) is also characterized by symplectite textures, type2-symplectite, with innermost sapphirine-cordierite symplectite followed by cordierite corona. Sapphirine in type2-symplectite domain (XMg: 0.89; Al/Si: 5.92), which occurs as inclusion in Opx, is chemically distinct than sapphirine occurring in texturally similar type1 symplectite domain. Orthopyroxene porphyroblast records largest rim-ward decrease in Al_2O_3 (core: ∼ 8 wt%; rim: 4.4 wt%). Also this domain lacks any veneer of meso-perthitic feldspar. P, T condition of M2 metamorphism is constrained at 7.5 kbar, 900 ºC indicating a second stage of near-isothermal decompression (Opx+Sil = Spr + Crd).

Monazites though occur as small inclusion (40 μm) in orthopyroxene porphyroblast, are predominant and larger (>100μm) in the biotite-feldspar defining leucosome domain suggesting melt-crystallization-assisted growth of monazite. Consequently, 560 Ma ages, which is recorded either uniformly from Opx-included monazite or from the core of matrix monazite, qualify to peak M1A and M1B metamorphism. The age relation further re-affirms that MB is a part of the transcontinental Pan-African granulite block that formed during Gondwanaland assembly and extends across Madagascar-India-Antarctica. As documented recently, final juxtaposition of MB with Archean Dharwar craton to the north was during Cambrian and marked by the closure of paleo-Mozambique Ocean along the Palghat Cauvery Shear Zone. Importantly, younger ages of 496 Ma were recorded from the rim of matrix monazite grains. Without proper textural relation, significance of this age remains uncertain. However, we tend to believe that 500 Ma age corresponds to M2 retrograde metamorphism and final exhumation of the UHT granulite at Perumalmalai. If proven, this possibly coincides with the tectonic extrusion related domal uplift of the MB during the final stage of Gondwanaland assembly.