# Implications of Zn-Spinel + quartz association during high-grade metamorphic rocks of Trivandrum Block, southern India

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Coexisting spinel+quartz in aluminous granulites often considered a robust indicator of ultrahigh-temperature metamorphism. Here we describe eleven spinel+quartz (the association notation cannot be used without being defined, in any case it is irrelevant in the abstract) assemblages from distinct microdomains in three closely associated migmatite samples from the Kerala khondalite belt within the Trivandrum Block of southern India. Whole-rock geochemical data indicate high-Zn (157.3, 109.1, 67.0 ppm) content in the spinel-bearing samples whereas this value is low (31.1 ppm) in spinel-absent samples. Spinel closest to the leucosome domain has an $X_{Mg}$ [Mg/(Mg+Fe)] of 0.29-0.30 and shows the highest Zn contents (if you want to give these numbers, you must define the variable, as for $X_{Mg}$ above, e.g., Zn/(Mg+Fe+Zn)). Spinel from the less migmatised is less rich in Mg $X_{Mg}$ = 0.24-0.25 and Zn ($X_{Zn}$ = 0.07-0.08). Isochemical phase diagram sections show that the Grt-Sil-Spl-Qtz-Ilm-melt assemblage is stable only at relatively low-temperatures ($T$ ≈770-830 °C, $P$ ≈4.5-6 kbar) while the low-Zn microdomain has a larger stability field of c. 769 to 950 °C at pressures between *c*. 4.5-6 kbar. Petrographic observations and thermodynamic modeling indicate the peak-metamorphic assemblage (Grt-Sil-Spl-Qtz-Ilm-melt) was stable over a wide range of $P$-$T$ conditions, with peak metamorphism at around 920 °C at 5.5 kbar. From microstructural observations we infer a clockwise evolution trajectory for the UHT granulites in the Trivandrum block. Microstructurally-controlled, in-situ, EPMA-age dating of monazites from these rocks yields three age populations that correlate with the timings of prograde (*c*. 600 Ma), peak (*c*. 580 Ma) and retrograde (*c*. 520-500 Ma) metamorphism. These results demonstrate that low-Zn spinel in otherwise proven UHT rocks need not imply high-temperature conditions. This observation should motivate a re-evaluation of reports on natural Zn-bearing and absent spinel+quartz assemblages from high-grade terranes in the context of UHT metamorphism.

Keywords: spinel+quartz, ultrahigh-temperature metamorphism, partial melting, Gondwana

 