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# Tourmaline-bearing rocks in the Singhbhum shear zone, eastern India: Evidence of boron infiltration during regional metamorphism

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## ABSTRACT

Frozen-in reaction textures combined with mineral chemistry of tourmaline-bearing metamorphic assemblages provide valuable information about fluid-rock interaction during orogenesis. Tourmaline occurs in four distinct mineralogical associations in the Singhbhum Shear Zone (SSZ) of the Precambrian East Indian craton. The tourmaline-bearing rocks are associated intimately with pelitic to psammopelitic and quartzofeldspasthic rocks, including meta-granite. The rocks were affected by two sets of folding ($F_1$ and $F_2$) and ductile shearing associated with $F_1$ during ca. 1.6–1.8 Ga tectonic activity in this belt. Quantitative geothermobarometry and the stability relations of the metamorphic assemblages developed in the pelitic rocks establish the presence of two episodes of metamorphism; a prograde $M_1$ event that culminated at 480 ± 40 °C, 6.4 ± 0.4 kbar, and an $M_2$ event that caused retrogression of the $M_1$ assemblages.

Field and petrographic observations in combination with data on chemical composition of tourmaline indicate three stages of tourmaline growth. The earliest stage is represented by pre-tectonic (pre-metamorphic) greenish-yellow tourmaline cores in the tourmalinite from the Surda area (Association A). The textural relations demonstrate that in the second stage, greenish-yellow cores of oscillatory zoned tourmaline in the metagranite (albite + quartz + biotite + chlorite ± muscovite ± apatite ± magnetite, Association C), very fine tourmaline grains in muscovite schist (muscovite ± quartz, Association B) and greenish yellow cores of tourmaline in biotite-muscovite schist (biotite + muscovite + magnetite + chlorite + apatite+ quartz, Association D) crystallized during the $F_1$-$M_1$ events. Post-tectonic, greenish-blue tourmaline, belonging to the third stage, replaces the earlier tourmaline grains along their margins and cracks.

Compositionally, tourmalines of all four associations fall in the alkali group. Most of the data fall in the dravite field with a few analyses straddling the boundary between schorl and dravite. An abrupt compositional change was noted across the different color zones in the tourmaline grains. This change is explained by one or more of the coupled substitutions, $\square Al(NaR)_{-1}$, $CaR(NaAl)_{-1}$, and $Mg(Fe)_{-1}$, where R = Mg + $Fe^{2+}$ + Mn. Integrating the field, petrographic, and phase-compositional data, it has been demonstrated that tourmaline growth in the second and third stages was induced by infiltration-driven, B metasomatism during prograde metamorphism of the rocks. Deep-seated magma was the source of the B-bearing hydrothermal fluid.