

Decoding Fluid Evolution in Archean Gold Systems: Boron Isotopes and LA-ICPMS Trace Element Geochemistry of Tourmaline from the Dharwar Craton

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Tourmaline from the Chigargunta area of the South Kolar Greenstone Belt (SKGB) and the Gadag Greenstone Belt (GGB) of the western Dharwar Craton was investigated using boron isotope analysis and LA-ICPMS trace element geochemistry to understand fluid sources and mineralization processes. The $\delta^{11}\text{B}$ values in tourmaline from Chigargunta range from -8.9‰ to -3.2‰ , whereas Gadag tourmalines yield values from -11.4‰ to -8.6‰ . These compositions suggest a dominantly non-marine evaporitic or crustal fluid component, likely reflecting fluid–rock interaction during greenschist to amphibolite facies metamorphism. The slightly heavier boron signatures in Chigargunta samples may indicate greater magmatic or marine input compared to Gadag.

Trace element geochemistry from LA-ICPMS analyses further distinguishes the two populations. Chigargunta tourmaline is enriched in Fe, Mn, Zn, and Li, with moderate REE contents, whereas Gadag tourmaline exhibits higher concentrations of Ti, V, and Sr, and relatively flat REE profiles with minor Eu anomalies. These patterns reflect differences in fluid composition, host lithology, and redox conditions. Tourmalines from both regions plot in the Li-Fe type and show geochemical signatures characteristic of hydrothermal origin associated with orogenic gold systems.

The combined boron isotopic and trace element data suggest that tourmaline in both belts formed from metamorphosed hydrothermal fluids with distinct sources and evolution histories. Chigargunta tourmalines likely record mixing between magmatic and metamorphic fluids, whereas Gadag samples reflect crustal fluid dominance, possibly modified by interaction with mafic-ultramafic host rocks. These insights enhance the utility of tourmaline as a tracer for fluid evolution in Archean greenstone belts and support its role as a robust indicator mineral in gold exploration across the Dharwar Craton.