Contrasting tourmaline chemistry from late-Archaen orogenic gold deposits at Hutti and Hira-Buddini, eastern Dharwar craton, India: Implications for fluid source

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Textural and chemical features of tourmaline in the proximal alteration zones of the Hutti and Hira-Buddini deposits are: (i) warping of biotite-chlorite mylonitic foliation, (ii) inclusions in pyrite, and (iii) sharp decrease of Fe at rim. These imply (i) synchronous sulfidation of the wall rocks resulting in pyrite formation and (ii) early tourmalinization and its continuation until sulfidation of wall rocks and gold mineralization.

Tourmalines from Hutti are Mg-rich (X_{Mg}=0.63) while the unaltered rock is Fe-rich (X_{Mg}=0.30). Their high Al content (> 6 apfu) implies no substitution of Al by Fe^{+3} in the Z-site. The dominant substitutions observed are $MgFe^{+2}_{-1}$, and $\square AlNa_{-1}(Fe^{+2},Mg)_{-1}$. Participation of Fe^{+2} in most substitutions suggest a low Fe^{+3}/Fe^{+2} ratio, also supported by the compositions lying on the dravite-foitite trend. These observations suggest a reducing nature for the tourmaline precipitating fluid. The Mg-rich composition of tourmaline in Fe-rich amphibolite shows insignificant chemical control of the unaltered rock on the tourmaline chemistry and suggest their formation under high fluid by rock ratio [1]. Such Mg-rich, low saline (X-site vacancy upto 0.53) and reducing nature of the fluid is suggestive of a metamorphic source [1][2].

Tourmalines from Hira-Buddini belong to dravite-schorl series with relaively low Mg (X_{Mg}=0.53); low X-site vacancy (≤ 0.16) and show an oxy-dravite-povandrite (O-P) trend. Dominant substitutions observed are $Fe^{+3}Al_{-1}$, $Fe^{+2}Fe^{+3}(Al_{-1}Mg_{-1})$ and minor $NaMg(\square_{-1}Al_{-1})$. Al contents of < 6 apfu is possibly due to substitution of Al in the Z-site by Fe^{+3}, as evident from the substitution types and tourmaline compositions lying on the O-P trend. Tourmalines characterized by enrichment in Fe^{+3} and Na, depleted in X-site vacancy suggest oxidizing and relatively high saline fluid, which could be either from a meta-evaporitic [3] or a late stage granitic source [4].

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Earth's Carbon through Deep Time

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Earth's 4.567 billion year history is marked by a dramatic evolution in the chemical, physical, and biological roles of carbon [1,2]. Aspects of Earth's changing carbon cycle are revealed by a variety of investigations, including: (1) Abiotic organic systhesis, notably mineral catalyzed reactions of volcanic gases, yield essential biomolecules. Recent findings point to the critical role played by hydrogen fugacity in the synthesis and stability of these molecules [3]. (2) Small organic molecules display competitive and cooperative adsorption on mineral surfaces. We find that adsorption configurations are strongly affected by environmental conditions such as pH, ionic strength, and solute concentration [4]. (3) Experimental, theoretical, and field studies elucidate serpentinization reactions, as well as other deep interactions between C-bearing fluids and mafic and ultramafic rocks. Both volcanic and impact hydrothermal zones led to the first extensive carbonate mineral production [5]. (4) The subsurface biosphere modifies and cycles carbon. Deep microbial life often survives at metabolic rates and in concentrations far below those of near-surface communities [6]. And (5) carbon mineral evolution traces the changing diversity, distribution, and compositions (including trace and minor elements) in carbon minerals through deep time. Diamond was the first mineral in the cosmos, but many of the almost 400 known carbon minerals have appeared only recently in Earth history [7]. Collectively, these and other investigations of Earth's carbon through deep time underscore the co-evolution of the geosphere and biosphere.

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