Title of the thesis: Petrological characterization of tourmaline bearing rocks from parts of South Purulia Shear Zone (SPSZ) and Singhbhum Shear Zone (SSZ): Evidence of episodic boron bearing fluid flux during regional metamorphism

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ABSTRACT

Tourmaline is an important borosilicate mineral, which has a complex chemical formula, high chemical resistance and a wide P-T stability field. Chemical composition of tourmaline is sensitive to ambient physicochemical conditions of its growth and thus provides valuable information about fluid-rock interaction in associated magmatic or hydrothermal systems, nature and evolution of its host rock.

The Eastern Indian Shield comprises of Paleo to Meso-Archean Singhbhum Craton towards the south and Meso-Proterozoic Chotanagpur Granite Gneissic Complex (CGGC) in the north. A multiphase-deformed and poly-metamorphosed volcano sedimentary succession of Palaeo- to Meso Proterozoic age known as the North Singhbhum Mobile Belt (NSMB) is juxtaposed between these two cratonic blocks. The NSMB is bound by two shear zones, viz. the South Purulia Shear Zone (SPSZ) in the north and the Singhbhum Shear Zone (SSZ) in the south. Both SPSZ and SSZ are characterized by regional shearing, hydrothermal activity and are known for hosting important polymetallic deposits. Intense infiltration driven metamorphism yielded several exotic rocks in SPSZ and SSZ including tourmaline mineralization. The SPSZ consists of schists (retrograded rocks of CGGC) and phyllites (Chandil formation of NSMB) that are highly deformed and hydrothermally altered. The SSZ is represented by an assemblage of polyphase-deformed, volcano-sedimentary assemblage of NSMB rocks. Notable tourmaline mineralization occurs within the schists, phyllite and pegmatites of SPSZ and kyanite-quartzite rocks of SSZ.

In the present study, a comprehensive field, petrographic, mineralogical and geochemical study of tourmaline-bearing rocks occurring at selected locations of SPSZ and SSZ is attempted. Within SPSZ, tourmaline mineralization occurs within pegmatite veins at Haripaldih area, muscovite/quartz-muscovite schist at Beldih area, mica-chlorite schist at Mukutmanipur area and phyllitic rocks at Kutni area. From field, textural and mineral compositions, two stages of tourmaline mineralization are identified in the SPSZ. The first stage of tourmaline mineralization (Gen-I) occurs within banded or laminated-quartz tourmaline rock within schistose rock and phyllite, where the tourmaline grains are oriented parallel to the S_1 regional fabric. The second generation (Gen-II) of tourmaline is characterized by coarse, haphazardly oriented grains without any prior deformational features within the schistose rock and quartz vein. Therefore, it is inferred that the Gen-I tourmaline is syn-tectonic with respect to the regional deformation (D_1) and Gen-II tourmaline postdates the latest deformation event in the area, i.e. D_3/F_3. However, another set of tourmaline mineralization is found within the pegmatite vein in Haripaldih area. These pegmatite veins are co deformed with the regional foliation i.e., S_1 fabric and tourmaline mineralization occurred as post tectonic with respect to S_1/D_1 but prior or syn-tectonic with respect to D_2. The Gen-I tourmalines in Beldih and Mukutmanipur region belong to alkali group and majorly of schorl (X_{Mg}=0.43-0.57) composition. Gen-I tourmalines from Kutni area belong to alkali to X-vacancy group and are foitite to Mg-foitite (X_{Mg} =0.46-0.58) in composition. The variation of tourmaline composition of same generation (Gen-I) is attributed to difference in host rock lithology. Gen-II tourmaline grains are dravite (X_{Mg} =0.55-0.69) in nature. Tourmalines in pegmatite in Haripaldih region belong to alkali group and their composition straddles

boundary between schorl and dravite (X_{Mg} =0.40-0.52). Major element composition suggests a low to moderate saline hydrothermal fluid was responsible for tourmaline mineralization across the SPSZ.

Around Ujainpur area of the SSZ, three generations of tourmaline mineralization were identified within the kyanite-quartzite. Gen-I tourmaline grains occur along the S_1 fabric that cut across and replaced by medium to coarse grained tourmaline aggregates. The latter are assigned to Gen-II which also preferentially grows along the S_2 shear foliation corresponding to the regional shear deformation (D_2) in SSZ. Gen-II tourmalines are associated without (Gen-IIA) or with (Gen-IIB) dumortierite. Another set of tourmaline (Gen-III) vein cut across the S_2 that are randomly oriented (post shearing or S_2). Gen-I tourmalines belong alkali to X-vacancy group and dravite to Mg-foitite (X_{Mg} =0.72-0.90) in composition. Gen IIA tourmalines belong to alkali group and dravite (X_{Mg} =0.62-0.71) in composition. Both Gen IIB (X_{Mg} =0.48-0.61) and Gen-III(X_{Mg} =0.35-0.45) tourmalines belong to X-vacancy group and foitite to Mg-foitite in composition. Chemical composition of Ujainpur tourmalines, it is inferred a high to moderate saline hydrothermal fluid may have been responsible for tourmaline mineralization in SSZ.

Tourmaline from the kyanite-quartzite rocks of SSZ exhibit distinctly higher REE concentrations (up to 1029 ppm) compared to those of the SPSZ (up to 15ppm). The SPSZ tourmalines exhibit distinct LREE enrichment, prominent positive Eu anomaly and flat to marginally convex upward HREE with respect to chondrite. The tourmaline within kyanite-quartzite of SSZ exhibits overall flat LREE and HREE chondrite normalized patterns along with weak negative to positive Eu anomalies. Tourmaline with higher concentration of Ca in its structure can accommodate LREE than HREE. Tourmalines along SPSZ has a significant amount of Ca (0.10 to 0.35 apfu) and thus are enriched in LREE due to Ca-LREE substitution. Contrastingly, low Ca (0.02-0.07apfu) SSZ tourmalines explain absence of LREE-enrichment and no significant LREE/HREE fractionation. Tourmaline from both SPSZ and SSZ shows prominent depletion in LILE such as Rb and Ba. Notably. These tourmalines have near-crustal concentrations of Sr, Ni, Co, Zn, V and Sc. Tourmalines of SPSZ have lower concentrations of Li and Y compared to the SSZ tourmalines. These features indicate that a metamorphogenic fluid may have taken significant role in tourmaline mineralization in SPSZ. However, in SSZ, the fluid responsible for tourmaline mineralization was possibly a combination of external, granite derived fluid and internal, metamorphogenic fluid. Based on the existing geochronological database and the relation between tourmaline texture and deformation fabrics, the present study suggests that tourmaline mineralization in SPSZ is younger than ~0.93 Ga whereas tourmaline mineralization in SSZ hosted by kyanite-quartzite is definitely older than 1.0 Ga.

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