

SHORT COMMUNICATION

CHEMICAL COMPOSITION OF TOURMALINE IN METARHYOLITE NEAR MAJJUR, GADAG SCHIST BELT, KARNATAKA

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Tourmaline mineralisation is associated with fine to medium grained schistose metarhyolite near Majjur within the Gadag schist belt, which is well known for hosting lode type of gold mineralisation largely in metavolcanic rocks. Tourmalines of prismatic habit oriented parallel to the schistosity and as basal sections developed perpendicular to the schistosity are observed. Microprobe analysis of these tourmalines reported here for the first time shows that they represent the end member compositions of Schrol-Dravite solid solution series. No distinct chemical or optical zoning is observed in either type of these tourmalines. These tourmalines are present in the outer fringes of the alteration zone developed around the gold mineralized zones in associated rocks. An attempt is made here to relate the chemical compositions of the tourmalines, *vis-a-vis* their occurrence in the alteration zones and the nature of boron metasomatism.

Introduction

Gadag schist belt, which forms the northern continuation of the well-known middle to late Archaean Chitradurga schist belt, consists predominantly of metavolcanics and metasedimentary sequences belonging mainly to the Chitradurga group (Swami Nath and Ramakrishnan, 1981). Gold mineralisation in different lithological units constituting the Gadag schist belt has been described by Ugarkar and Deshpande, (1999) who have suggested a structurally controlled metamorphic hydrothermal model in which gold mineralisation was probably co-eval and does not favour any particular lithology. The distribution of quartz lodes and gold are summarized by Curtis and Radhakrishna (1993). The main lithologies found in the Gadag schist belt are basic and acid volcanics, greywacke, banded iron formations, conglomerate and chlorite-sericite phyllites. Gold mineralisation associated with banded iron formations has been reported with an average grade of 2.10 g/t over a width of 4.31-5.46 m mainly in the middle shear zone in

the northern portion of Gadag schist belt (Beeraiah et al. 2001).

Petrographic Characteristics

Tourmaline occurs in fine to medium grained schistose metarhyolite in Majjur area in the western part of the Gadag schist belt (Fig.1). These schistose metarhyolites are associated with banded iron formations, metabasalts and shales/phyllites. Tourmaline occurs in two modes: the prismatic (oriented parallel to the schistosity and equidimensional, Fig.2) and the basal. Both the prismatic and the basal varieties of the tourmaline show homogeneity in chemical composition suggesting a single episode of their formation within the metarhyolite. While prismatic tourmaline is coarse to medium grained, basal sections are largely medium grained. Both prismatic and basal sections of the tourmalines are black in colour in the hand specimen and pinkish to yellow in thin section. Coarse grained prismatic tourmalines exhibit crosscutting fractures filled by medium grained quartz veinlets which terminate at the grain boundaries and do not continue into the schistose mica rich matrix (Fig.2). The matrix is made up of fine grained muscovite, sericite, quartz, calcite and illite and in deformed portions minor puckerings are observed along which the coarse grained prismatic tourmaline is bent. Modal percent of tourmaline is 35-40% and the remaining is constituted by the fine grained matrix minerals. Due to the well-developed schistosity in metarhyolite, the prismatic tourmaline shows largely a parallel orientation, while the basal sections are randomly oriented around which there is a veering of schistosity. While the prismatic tourmaline occurs in clusters and as discrete grains, the basal sections are always present in clusters. A few of the prismatic tourmalines are also formed along the axis of minor crenulation cleavages.

Mineral Chemistry

50 grains of coarse-grained tourmalines were analyzed

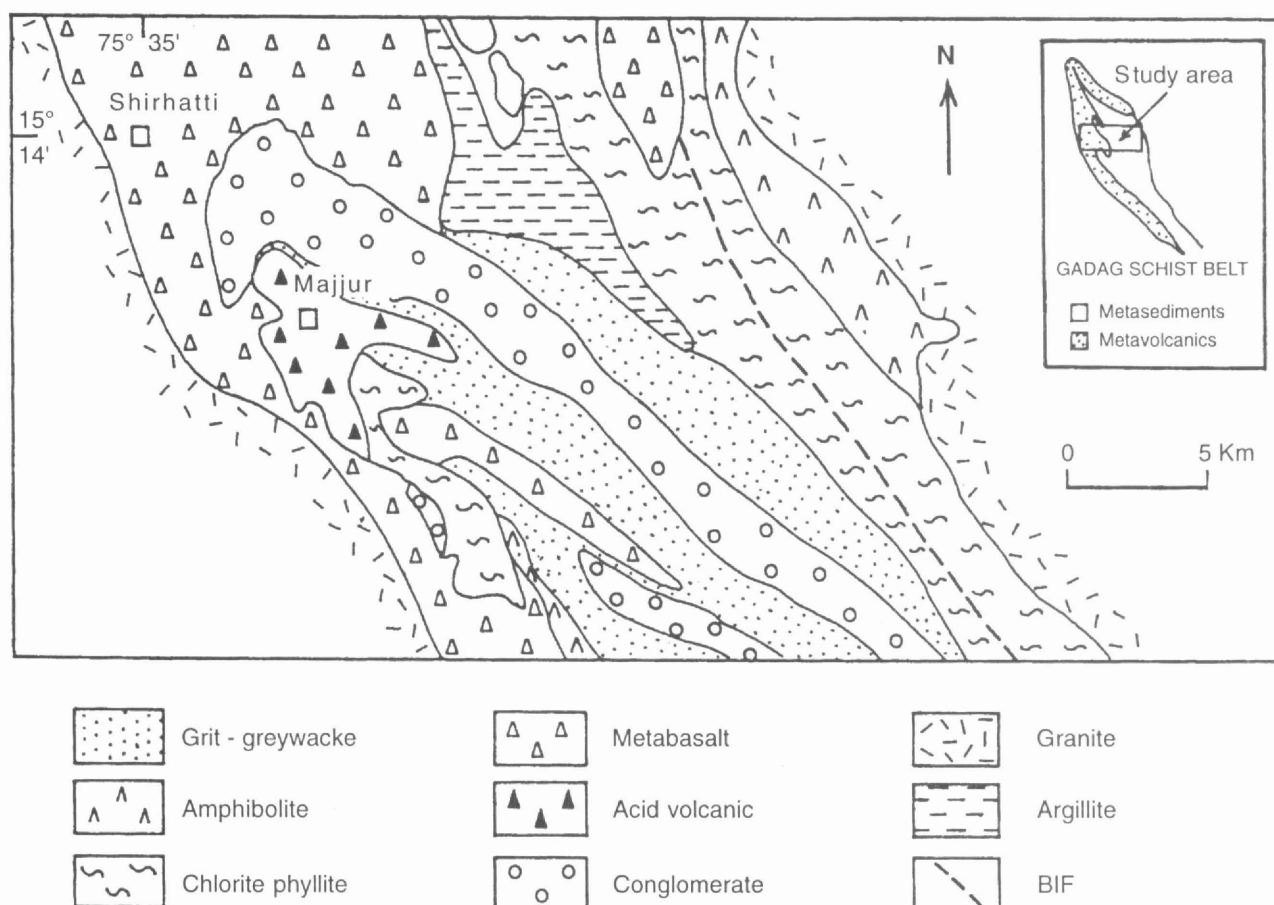


Fig.1. Generalised geological map of a part of the Gadag schist belt showing the location of Majjur metarhyolites. (after Ramachandran, T.V., et al. 2001)

in two polished and carbon coated thin sections (Table 1) using a CAMECA make Cambax-Micro Electron Probe Micro Analyzer (EPMA). The analytical conditions were 15 kV accelerating voltage, 18 nA beam current, 1m beam diameter and 10 sec counting time. Natural oxide and silicate mineral standards were used for calibration during the analysis and the on line ZAF correction programme of Henoc and Maurice (1978) was applied.

Structural formula for these tourmalines was calculated on the basis of 24.5 Oxygens by leaving three stoichiometric units for Boron after the normalization procedure suggested by Henry and Dutrow (1996). Compositional data of these tourmalines in terms of $\text{Fe}/(\text{Fe}+\text{Mg})$ and $\text{Na}/(\text{Na}+\text{Ca})$ ratios and the total Al content is depicted in Figs.3 A and B. $\text{Fe}/(\text{Fe}+\text{Mg})$ shows a range from 0.64 to 0.73, while $\text{Na}/(\text{Na}+\text{Ca})$ varies from 0.97 to 0.99. Chemical compositions of these tourmalines define the Schrol-Dravite end member series as shown in the $\text{Fe}/(\text{Fe}+\text{Mg})$ vs $\text{Na}/(\text{Na}+\text{Ca})$ plot (Fig.3A) though the $\text{Fe}/(\text{Fe}+\text{Mg})$ vs Total Al plot (Fig.3B) shows a light scatter which is a reflection of the total Al

content in tourmalines (Trumbull and Chaussidon, 1999).

The source of boron to form tourmaline can be either hydrothermal fluids or other boron bearing minerals. Because boron is a trace constituent in the upper crust, lower crust and the mantle, it needs to be concentrated by geochemical processes in order to form tourmaline and other boron bearing minerals (Henry and Dutrow, 1996).

According to Deb et al. (1997) if boron is not transported out of the system during metamorphism, the boron isotopic compositions of tourmalines will remain unchanged. Boron isotopic compositions of tourmalines indicate either hydrothermal fluids or a silicate melt as possible sources of boron (Trumbull and Chaussidon, 1999). Two important factors that control the stability of tourmaline are the abundance of ferromagnesian components and the availability of a fluid melt (London and Manning, 1995). Boron enrichment in rocks can take place when boron bearing hydrothermal or metamorphic fluids interact with suitable host rocks (Henry and Dutrow, 1996). Tourmaline formation in the metarhyolites at Majjur appears to be due



Fig.2. Photomicrograph of prismatic and basal sections of tourmalines and cross cutting quartz veins. Nicols crossed and length of the scale bar is 25 μ m.

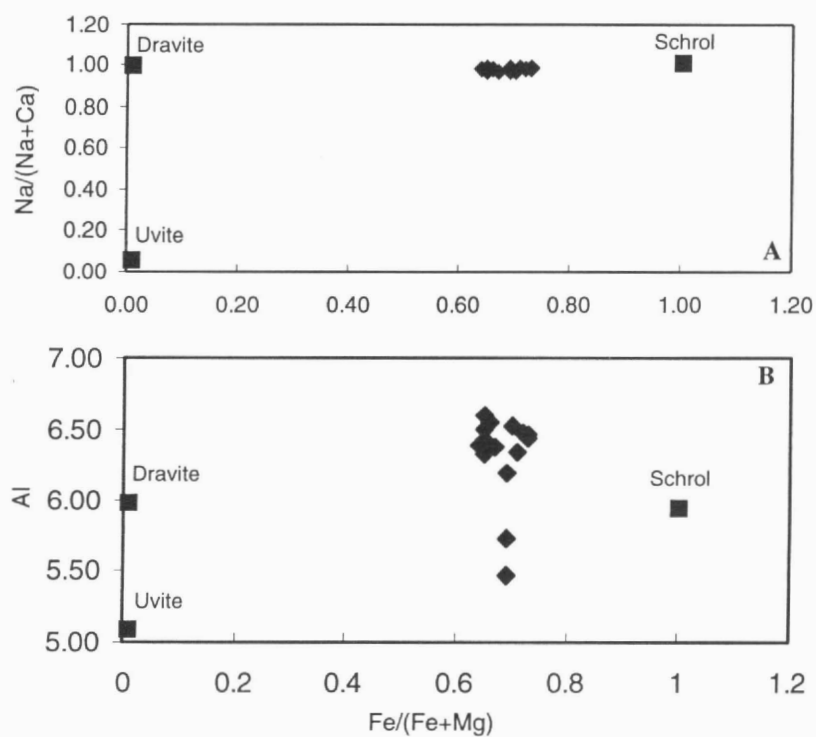


Fig.3. (A). Fe/(Fe+Mg) vs Na/(Na+Ca) diagram showing tourmalines defining the Schrol-Dravite end member series. (B). Fe/(Fe+Mg) vs Al diagram showing variation in Al content of the tourmalines.

Table 1. Chemical composition of tourmaline from Majjur area, Gadag schist belt

	MajIB6R	MajIB8C	MajIB10R	MajIB12R	MajIB13R	MajIB15C	MajIB17R	MajIB20I	MajIC3I	MajIC9R	MajIC10C	MajIC12R	MajIC14C	MajIC16R	MajIC17C
SiO ₂	36.16	35.87	36.30	37.37	35.71	36.01	35.63	35.77	35.65	35.13	35.29	35.14	35.16	41.10	36.62
TiO ₂	0.07	0.04	0.04	0.10	0.03	0.04	0.01	0.05	0.14	0.06	0.10	0.07	0.01	0.05	0.14
Al ₂ O ₃	32.47	34.09	33.18	32.47	33.06	32.44	32.60	32.49	32.78	32.61	33.26	32.46	31.76	30.04	31.23
FeO	10.96	11.87	10.71	10.69	10.81	12.14	11.65	11.43	13.00	13.25	12.78	13.25	13.33	11.52	12.24
MgO	3.49	3.27	3.28	3.24	3.06	3.37	3.61	3.46	2.68	2.84	3.04	2.73	3.17	2.81	2.97
MnO	0.02	0.04	-	0.01	-	0.02	0.05	0.02	-	0.07	0.07	0.09	0.03	0.04	0.03
CaO	0.07	0.09	0.07	0.11	0.10	0.10	0.09	0.06	0.03	0.06	0.10	0.09	0.04	0.08	0.05
Na ₂ O	2.47	2.18	2.23	2.14	2.09	2.24	2.41	2.40	2.13	2.09	2.29	2.41	2.29	1.99	2.27
K ₂ O	0.06	0.07	0.08	0.10	0.05	0.09	0.06	0.04	0.06	0.06	0.11	0.06	0.07	0.08	0.05
Total	85.77	87.52	85.89	86.23	84.91	86.45	86.11	85.72	86.47	86.17	87.04	86.30	85.86	87.71	85.60
Structural Formula on the basis of 24.5 Oxygens															
Si	6.03	5.89	6.03	6.17	6.00	6.00	5.96	5.99	5.96	5.91	5.87	5.91	5.95	6.65	6.16
Al(z)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	5.73	6.00
Al(y)	0.39	0.60	0.50	0.32	0.55	0.38	0.42	0.42	0.46	0.47	0.52	0.44	0.34	0.00	0.19
Ti	0.09	0.005	0.004	0.010	0.003	0.005	0.001	0.006	0.017	0.007	0.010	0.008	0.001	0.060	0.018
Fe	1.53	1.63	1.49	1.48	1.52	1.69	1.63	1.60	1.82	1.86	1.78	1.86	1.89	1.56	1.72
Mg	0.87	0.87	0.81	0.79	0.77	0.84	0.89	0.86	0.67	0.71	0.75	0.68	0.79	0.68	0.74
Mn	0.003	0.003	0.000	0.001	0.000	0.002	0.007	0.002	0.000	0.009	0.009	0.010	0.004	0.005	0.004
Sum Y	2.88	3.11	2.80	2.60	2.84	2.92	2.95	2.89	2.97	3.06	3.07	3.00	3.03	2.31	2.68
Fe/Fe+Mg	0.64	0.65	0.65	0.65	0.66	0.67	0.65	0.65	0.73	0.72	0.70	0.73	0.71	0.69	0.69
Ca	0.013	0.016	0.012	0.019	0.010	0.020	0.020	0.010	0.005	0.010	0.017	0.016	0.007	0.013	0.009
Na	0.80	0.69	0.72	0.68	0.68	0.72	0.78	0.78	0.69	0.68	0.74	0.79	0.75	0.62	0.74
K	0.013	0.015	0.016	0.020	0.010	0.020	0.010	0.008	0.010	0.010	0.020	0.010	0.020	0.020	0.010
Sum X	0.83	0.72	0.75	0.72	0.70	0.76	0.81	0.80	0.71	0.70	0.78	0.81	0.78	0.65	0.76
Na/Na+Ca	0.98	0.98	0.98	0.97	0.98	0.97	0.98	0.99	0.98	0.98	0.97	0.99	0.99	0.98	0.99

to metasomatic fluid activity related to gold mineralisation in the area, during which boron was either introduced from an outside source (hydrothermal mineralizing solutions) or was probably leached from associated basic and argillaceous rocks containing boron bearing minerals during regional metamorphism. According to Henry and Dutrow (1996), at lower grades of metamorphism, clays can host significant amounts of boron and metasomatic reactions involving clay minerals can potentially release boron to form appreciable amounts of tourmaline. Therefore it is suggested that there is a possibility of this kind of reaction having taken place in a closed system for the formation of tourmaline due to the

proximity of an illite rich zone within the metarhyolite at Majjur. The Schrol-Dravite end member chemical compositions defined by these tourmalines suggest that they are of proximal to intermediate types in terms of the nearby gold mineralised zone, on the basis of their FeO/FeO+MgO ratios.

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