OCCURRENCE OF AUTHIGENIC TOURMALINES IN THE LOWER KALADGI QUARTZITIC SANDSTONES OF SAUNDATTI, MYSORE STATE

by B. V. Govinda Rajulu, *Department of Geology, University of Mysore, Mysore*
and
P. N. Satish, *Mineralogical Institute, University of Mysore, Mysore*

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This paper deals with the morphology, origin and significance of the different varieties of tourmaline, occurring in the Lower Kaladgi quartzitic sandstones outcropping around Saundatti and exhibiting authigenic growths. It is concluded that the diagenetic changes resulting in the growth of minerals belonging to the complex isomorphous series of the tourmaline group are controlled by neither the chemical composition of the detrital nor the host tourmaline grain.

Introduction

The Lower Kaladgi (Pre-Cambrian) formations of Saundatti (lat. 15° 46′, long. 75° 7′), Mysore State, comprise of quartzitic sandstones, shales and limestones resting unconformably over the basement granites. The general classification and their stratigraphical position are as follows:

Basalts	Deccan Traps
Sandstones	Badamis
Limestone	Kaladgis (Pre-Cambrian)
Shales	
Pebbly quartzitic sandstone	
Grey quartzitic sandstone	
Pink quartzitic sandstone	
Basal conglomerate	
Granites, dolerites, biotite schist, hornblende-schist, chlorite schist, epidiorites, calc granulites, and banded ferruginous-quartzite	Archaeans

The Kaladgi sediments of Saundatti, being the southernmost fringe of the main Kaladgi basin, have a general east-west trend with their dips ranging from 7° to 20° N. The quartzitic sandstones show current bedding, ripple marks, sun cracks and rain prints. They are fine grained to medium grained, being almost made up of quartz (90 to 95 per cent), and can suitably be termed as orthoquartzites, except for the pebbly quartzitic layer which contains felspars making it subarkosic. Tourmaline, zircon, rutile, chlorite, sericite and hornblende are among the heavy accessories.

The study of heavy mineral mounts and micro-sections of these quartzites reveals the presence of tourmalines with distinct authigenic growths.

DESCRIPTION

The detrital nature of most of the tourmaline grains is clear. Depending on the shape and degree of roundness, they can be termed as very well rounded and angular, according to Krynine and Tuttle. The detrital grains and the new growths are distinct from each other in dichroism exhibiting varying shades of yellow, blue, green, brown, etc. On the basis of dichroism and birefringence, the tourmalines under study have been roughly categorized into the respective members of the isomorphous series as follows:

Heavy mounts		
Schorlite	usually black, dark green	purplish brown, greenish brown
Elbaite	pink, pale green, greenish blue	colourless
Dravite	dark yellowish brown	pale yellow
Chromium tourmaline	dark green	pale green, greenish yellow

Micro-sections (0·03 mm.)			*Birefringence*
Schorlite	yellowish brown, black, dark green, blue of various shades	pale to dark yellow, brownish, pale violet, green, yellowish	0·024–0·035
Elbaite	colourless, pink, pale blue	colourless	0·015–0·023
Dravite	pale yellow	colourless	0·022–0·025
Chromium tourmaline	green to bluish green	pale yellow	0·035–0·046

Alty (1933) and others have described the authigenic portion to be colourless and the detrital grain as strongly dichroic. But the overgrowths on the tourmalines described here show distinct dichroism, and in some may even be considered to be strong. The average birefringence of the host is 0·022 while that of the overgrowth is 0·013 (as determined by Berek's compensator). They are optically negative.

Among the tourmalines, apart from the authigenic development at the termination of the 'c' axis (Alty 1933—Figs. 1, 3 and 7), growths are also observed on the prismatic face of the host (Fig. 6), and in some, the overgrowths completely envelop the host grains (Figs. 2, 4, 5 and 8).

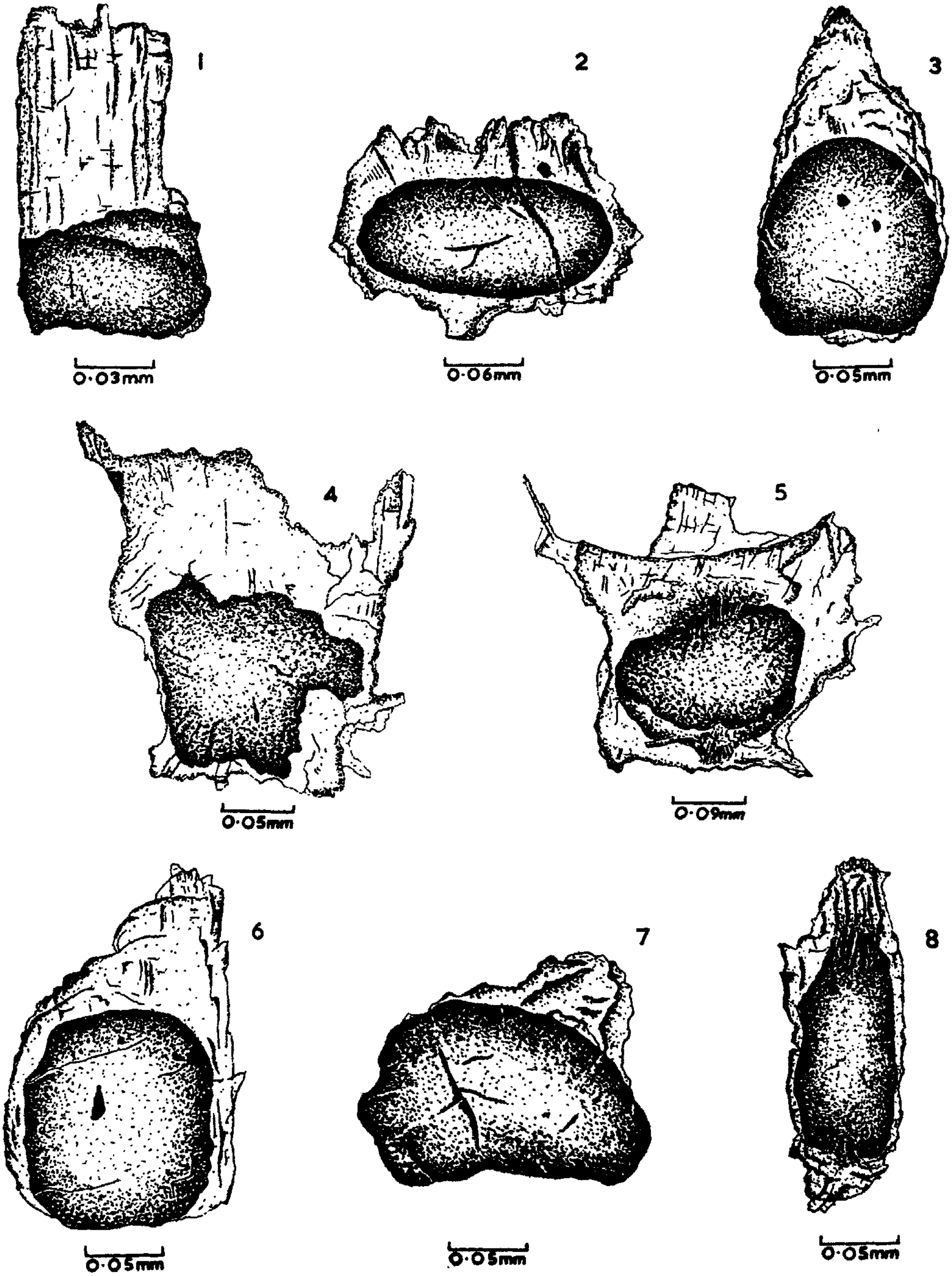
The overgrowths greatly vary in size. A few of them have attained the size of the host while there are some whose development is so much stinted as to appear as mere rims around the detrital grain or as small protuberances. Some others do show an exaggerated growth which may be twice or even thrice the size of the nucleus (Figs. 4, 5). The largest overgrowth noticed so far is that of elbaite measuring 0·300×0·017 mm which has developed on a detrital grain of schorlite measuring 0·150×0·117 mm. The sizes (in mm) of the tourmaline grains and the overgrowths are tabulated below.

	Maximum	Minimum	Average
Host ..	0·8×0·3	0·045×0·03	0·153×0·096
Overgrowth ..	0·3×0·067	0·024×0·003	0·088×0·027

Among the host grains schorlite is the most abundant contributing about 66·2 per cent of the total, followed by dravite which is about 14·3 per cent. Elbaite and chromium tourmaline are the least, accounting for the rest with 9·6 per cent each.

On the other hand, among the overgrowths, elbaite accounts for 61·9 per cent, followed by chromium tourmaline 23·9 per cent, schorlite 9·6 per cent and lastly dravite which is about 4·9 per cent.

	Nuclei percentage	Overgrowths percentage
Schorlite ..	66·2	9·6
Elbaite ..	9·6	61·9
Dravite ..	14·3	4·9
Chromium tourmaline	9·6	23·9



Figs. 1, 3 and 7. Authigenic development at the termination of 'c' axis. Fig. 6. Authigenic growth on the prismatic face of the host. Figs. 2, 4, 5, 8. Authigenic growths completely enveloping the host grains. The zone of the roots or reorganization clearly observed in Figs. 5 and 8.

The host grains usually contain inclusions whereas the overgrowths are generally devoid of them and invariably clear. It is not possible to identify the inclusions due to their submicroscopic nature. The overgrowths have a relatively lower relief than the host and are normally found to be angular, with striations and slight fractures. The zone of roots or reorganization is clearly displayed by some of the grains (Figs. 5, 8). In most of the grains perfect optical continuity is observed between the overgrowth and the host, but in a few, slight deviation in optical continuity may be observed as indicated by slight difference in the extinction position of the two. This may be attributed to slight variations in their optical orientation.

DISCUSSION

Alty (1933) reported authigenic tourmalines from the Lower Devonian sediments of Canada and Krynine (1946) from various geological units. In India they have been reported from the Sathyavedu stage (Gundu Rao 1952), the Gulcheru stage of the Cuddapahs (Viswanathiah *et al.* 1963), the Lower Kaladgis of Badami area (Viswanathiah and Govinda Rao Sindhia 1966), from the Lower Kaladgis of Jamkhandi (Govinda Rajulu and Nagaraja 1968), and from the Vindhyan formations of Sone Valley, Mirzapur district (Awasthi 1961).

Various authors in the last few years have drawn attention to some of the factors connected with the authigenic tourmalines. Special mention should be made of Krynine's (1946) excellent work on tourmalines which is highly informative and has proved to be extremely useful in the present study. Based on the colour and morphology of the grains he has recognized five types of major provenances. Making use of his concept, the source for the tourmalines under report can be traced to granitic and pegmatitic provenances. Thus the small idiomorphic tourmalines of dark brown, green or pink colours, with cavities and bubbles are assumed to have been derived from a granitic terrain. Similarly the bigger bluish to greenish blue grains, with fewer inclusions, are suggestive of a pegmatitic parentage.

There is a marked fluctuation in the degree of roundness of the detrital tourmaline grains. Various shapes ranging from angular to well rounded can be observed. Apart from the grains with authigenic growths, there are also prismatic, acicular and euhedral grains which appear to be considerably fresh. This contrast coupled with the different degree of roundness of the grains are the supporting evidences in favour of different provenances.

The authigenic tourmalines speculated to be rare and belonging to the anadiagenetic phase (Fairbridge 1967) have developed new growths by selective absorption of certain chemical constituents from the percolating solutions. They are the probable products of a reaction between the ions of a boron and alumina-rich interstitial water and the primary (detrital) particles, which have acted as nuclei during lithification and diagenesis of the parent rock in the depositional basin. Each of the three diagenetic phases (syndiagenesis, anadiagenesis and epidiagenesis) are characterized by certain suite of authigenic minerals.

Apart from tourmalines, authigenic growths are also observed in quartz, zircon and sericite. The development of these new growths as a result of diagenesis breeds an interesting study and the process itself is known to be influenced by the nature of the overlying basin water and their fluctuations of oxidation-reduction potential (Eh), hydrogen ion potential (*p*H) and concentration of the concerned ions. The interstitial waters acting as agents of these ions, on saturation, might have led to the precipitation of diagenetic minerals. It is more likely that the minerals and ionic solutions which existed in the fresh Kaladgi sediments were in a state of chemical inequilibrium. To fabricate a state of equilibrium, a chain of events could have been set in motion, whose rates and directions were controlled by the environment. During this resuscitation of equilibrium, selective absorption by ageing gels have led to new minerals and can, therefore, be considered as a vital process in authigenesis.

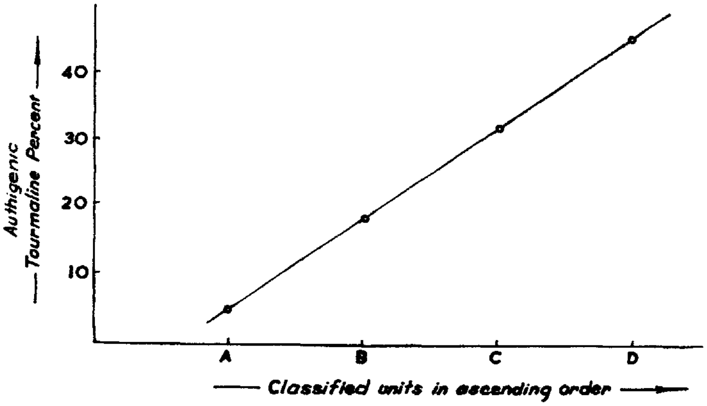


FIG. 9. Graphical representation of the average percentage frequency of authigenic tourmaline for the arenaceous horizons (A, basal conglomerate; B, grey quartzite; C, pink quartzite; and D, pebbly quartzite).

Furthermore, evidences like current bedding, ripple marks, sun cracks, rain prints, etc., found in the parent rock indicate that the authigenic growths have developed under shallow water conditions.

In order to study the horizontal and vertical variations of tourmalines in all the stratigraphic units, 56 representative rock specimens were selected from 14 traverses at regular intervals. Thus each traverse had four specimens representing all the four horizons. Heavy minerals were separated from all these specimens and the tourmaline grains were counted. The average number of tourmaline grains for each traverse works out to be 566 grains, out of which 46 grains show authigenic development and the rest are non-authigenic. Lateral variations of tourmaline grains are completely neglected as they hardly show any noticeable fluctuations, and each individual unit maintains a uniformity from one end to the other. On the other hand, the vertical variations are well defined when all the four units are taken into consideration, as represented in the graph (Figs. 9 and 10). The average percentage frequency of 46 authigenic and 520 non-authigenic tourmaline grains for each arenaceous horizon are calculated and plotted on the graph accordingly.

In Fig. 9, the representative percentages of authigenic tourmalines in each horizon are calculated for the average 46 grains and represented on the graph. The least number of authigenic growths is in the basal conglomerates amounting to about 4·5 per cent and gradually increases to the maximum in the topmost pebbly quartzitic sandstone beds to about 45·4 per cent. This may also suggest a gradual increase of the suitable chemical ingredients in the percolating waters during deposition, cementation and diagenesis of the sediments. This evidence may help to unravel some of the aspects of the palaeogeographical conditions.

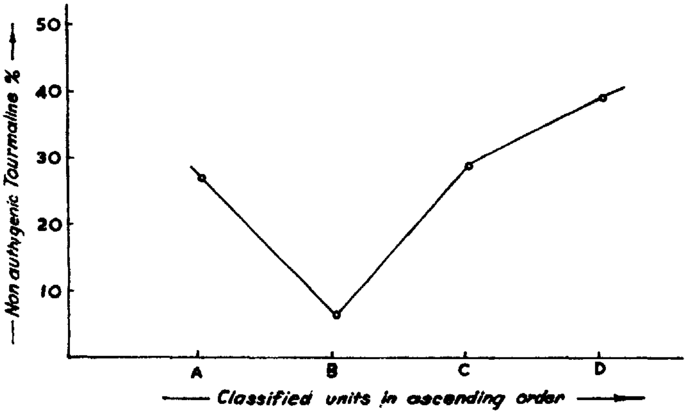


FIG. 10. Graphical representation of the average percentage frequency of non-authigenic tourmaline grains for the arenaceous horizons (A, basal conglomerate; B, grey quartzite; C, pink quartzite; and D, pebbly quartzite).

In Fig. 10, the percentage distribution of the average 520 grains per traverse of non-authigenic tourmalines is calculated and plotted in a similar manner. The basal conglomeratic bed contains 26·9 per cent of the total number of grains. Here, most of the tourmalines are prismatic, euhedral, pale green or pale blue in colour and sometimes colourless. There is a sudden drop to 5·8 per cent in the immediately overlying pink quartzitic sandstone. From here onwards there is a gradual increase in the successive beds which reaches the maximum of 38·6 per cent in the topmost horizon of pebbly quartzitic sandstone. The tourmalines from the pink quartzite and upwards are mostly well rounded, dark brown, green or pink in colour. But in the last pebbly horizon there is a mixture of well rounded, angular and also small prismatic euhedral grains.

From these evidences it is surmised that the tourmalines of the basal conglomerate might have been derived from the underlying basement granites and pegmatites. The supply of tourmalines from this source seems to have stopped during the formation of pink quartzites. The nature of the tourmaline grains present here suggests a different percentage, while those that occur in the uppermost horizon of pebbly quartzite appear to have been derived from more than two terrains.

CONCLUSION

The clear-cut differences in the varieties of tourmalines between the host and the overgrowth, like elbaite on schorlite, dravite on schorlite and the converse, etc., may probably indicate that the detrital grain of tourmaline is not dependent on the identical chemical composition of the complex isomorphous series of the group, to develop an authigenic growth.

The investigation has also proved the utility of both authigenic and non-authigenic tourmalines in certain sedimentological studies like tracing the relationship between the different horizons of a basin, viz. the Kaladgis, and thus may be applied to similar formations elsewhere. Further the concepts discussed above may also prove to be helpful in solving other problems like classification and correlation of sediments, and reconstruction of palaeogeographic conditions. Similarity of depositional environment can also be traced as between the four stratigraphic horizons of the Lower Kaladgis exposed around Saundatti and Jamkhandi respectively (Govinda Rajulu and Nagaraja 1968). It is significant to point out that among the authigenic tourmalines observed in the Kaladgis of Jamkhandi, schorlite and elbaite constitute 60 and 50 per cent respectively among the host grains and the overgrowths. Almost similar data, viz. schorlite (66·2 per cent among the hosts) and elbaite (61·9 per cent among the overgrowths), are obtained in the present investigation where the Lower Kaladgi sandstones of Saundatti are involved.

The development of authigenic minerals in general throws light on the physico-chemical environment which existed in the sediments upon deposition and also helps in defining the physico-chemical boundary limits of diagenesis. We are sure that similar data will be of great use when the tourmalines of the entire Kaladgi basin and also its equivalent formations are studied.

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