Can Detrital Tourmaline Provide Stratigraphic Fingerprints? Initial Tests in the Western Himalaya

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The locations and definitions of stratigraphic units in the western Himalaya are controversial. This limits our ability to identify and to reconstruct slip upon the major structures. We investigated the use of the chemistry populations of detrital tourmaline as signatures to correlate and discriminate stratigraphic units in the western Himalaya.

Detrital tourmaline has been used as a provenance indicator because of its chemical variations and stability. Previous studies examined the molecular proportions of Al, Fe, Mg and Ca in tourmalines and showed that different source-rock types have different major-element chemistry (Henry and Guidotti, 1985). Other elements (Na, Mn, K, and Ti) can also be used. We tested if this tool could (1) correlate the Haimanta Group with the Shimla Group and the Greater Himalaya Crystalline complex (GHC); (2) discriminate these late Proterozoic sequences from Early Proterozoic sequences in the western Himalaya. Our results are mixed, showing some promise and indicating some limits for the application of this tool in Himalayan studies.

We obtained electron-microprobe analyses of tourmaline chemistry of samples from the Shimla Group, the Berinag Group, the Damtha Group, the Haimanta Group, and the Greater Himalaya Crystalline. We attempted to separate tourmalines from three Shimla Group samples, two Berinag Group samples, three Damtha Group samples, four Haimanta Group samples and four Greater Himalaya Crystalline samples. Among those samples, one Shimla sample, one Berinag sample, one Damtha sample, three Haimanta samples and two Greater Himalaya Crystalline samples yield tourmalines. The analyzed Berinag Group sample is recrystallized orthoquartzite. The tourmalines are euhedral and observing zoning under cross-polarized light and backscatter imaging does not reveal detrital cores. The analyzed Shimla Group and Damtha Group samples are sandstones dominated by detrital quartz grains with minor micas. Tourmalines are rounded and show cores and thin-overgrowth rim zoning. The Haimanta Group samples are phyllite and garnet mica schist. Out of ~100 tourmaline grains, 25 of them show rounded detrital cores under cross-polarized light and on backscatter images. One Greater Himalaya Crystalline complex sample is schist with quartz, plagioclase, kyanite, garnet and mica. The tourmalines are euhedral and homogenous. They do not show rounded detrital cores under cross-polarized light. The other Greater Himalaya Crystalline complex sample is gneiss with quartz, plagioclase, garnet and mica. The tourmalines in this sample are heterogeneous and show rounded detrital cores with overgrowth-rim zoning.

We plot data from the detrital tourmalines (as determined by textural and zoning evidence described above) in Figure 1. This x-y plot shows Al-Fe-Mg composition in molecular proportions of detrital tourmaline (modified after Henry and Guidotti, 1985). Eight different zones are defined on the basis of different source rock types (see figure caption for specific zone definition). 96 detrital tourmalines from the Shimla Group sample have populations concentrated in zones B and D, 25 Haimanta detrital tourmalines distribute in zones D, E and F, 90 detrital tourmalines from the Damtha Group sample spread evenly across zones B, D, E and F. The Greater Himalaya Crystalline only has 10 detrital tourmaline analyses; these plot in zones B, D, F and G. The analyzed Berinag tourmalines have a very distinctive pattern with two highly concentrated clusters in Al-Fe-Mg and Ca-Fe-Mg binary diagrams. The metamorphic GHC tourmalines show one concentrated cluster in both diagrams.

The chemistry patterns of the Berinag Group tourmalines and most GHC tourmalines likely represent metamorphic growth phases. The analyses of Shimla, Haimanta, and Damtha detrital tourmalines appear sufficient to meaningfully distinguish these populations. Only the Damtha Group and Shimla Group feature low-Mg tourmalines. The Shimla Group and the Damtha Group are distinct, because the Damtha Group tourmaline compositions define a more significant presence in zones E and F (22 vs. 5), with a near absence of Shimla results in zone F (13 vs. 1). Interestingly, the high-temperature (~650-700 °C) Greater Himalaya Crystalline sample preserves detrital tourmalines, while the lower-temperature (~450 °C) Berinag Group sample does not. Finding detrital tourmalines and using their chemistry to establish signatures are the keys to fully apply this tool in differentiating and correlating stratigraphic units.

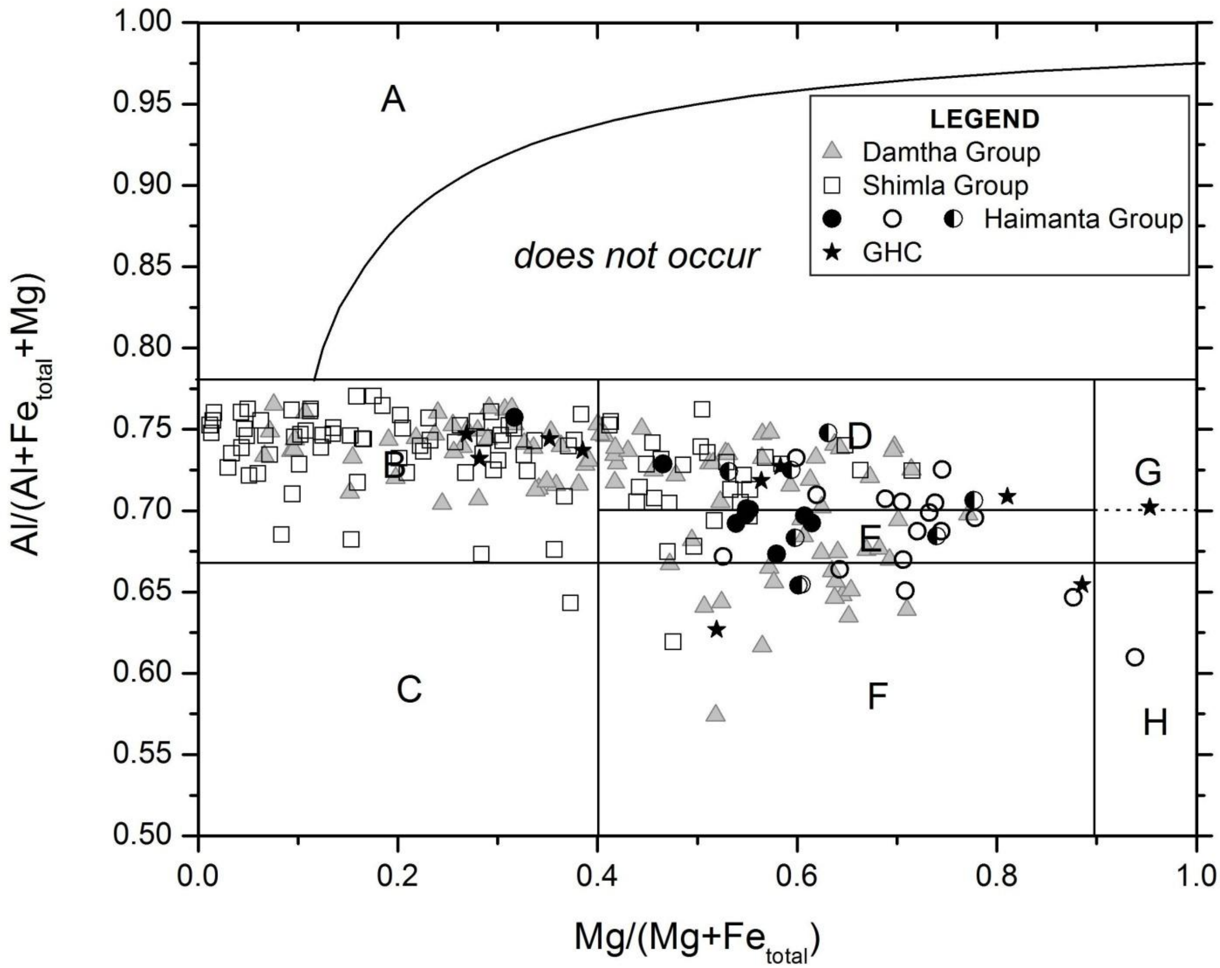

Figure 1. Al-Fe-Mg diagram (in molecular proportions) for detrital tourmalines from Damtha Group, Shimla Group, Haimanta Group and GHC. Zone A—Li-rich granitoids, pegmatites and aplites. Zone B—Li-poor granitoids, pegmatites and aplites. Zone C—hydrothermally altered granitic rocks. Zone D—Aluminous metapelites and metapsammites. Zone E—Al-poor metapelites and metapsammites. Zone F—Fe^{3+}-rich quartz–tourmaline rocks, calc–silicates and metapelites. Zone G—Low Ca ultramafics. Zone H—metacarbonates and metapyroxenites (plot and zones modified after Henry and Guidotti, 1985)

References

Henry D. J. and Guidotti C. V., 1985, Tourmaline as a petrogenetic indicator mineral: an example from the staurolite-grade metapelites of NW Maine, American Mineralogist, 70, 1-15,

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