Stability of Fe-Mg tourmalines: insights from phase equilibria experiments in the system MgO-(±FeO)-Al_2O_3-SiO_2-H_2O-NaCl-B_2O_3 at 400-650 °C and 3 kbar

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Tourmalines are stable in a wide range of pressure-temperature condition and they occur in diverse magmatic, metamorphic and hydrothermal environments. The composition of tourmalines is considered to reflect the chemistry of the media they have formed in and has been widely used as a proxy in petrogenetic studies and mineral exploration targeting. However, quantitative modeling of natural tourmaline compositions is currently not possible due to the lack of reliable thermodynamic data for its end-members and insufficient experimental constraints on tourmaline phase equilibria. Of particular importance would be experimental studies of Fe-bearing solid-solutions of hydrothermal tourmalines which are not available.

We present the results of experimental phase equilibria studies in the system MgO-(±FeO)-Al_2O_3-SiO_2-H_2O-NaCl-B_2O_3 at 400-650 °C and 3.0 kbar. Two series of experiments were performed in (1) the pure Mg and (2) Mg-Fe binary system. The experiments were designed to establish the stability of tourmalines and coexisting mineral phases, to investigate the element partitioning between tourmaline and coexisting phases, and to investigate internal elemental substitutions of tourmaline. The stable phases coexisting with tourmaline in the experiments are talc, chlorite, quartz and amphibole. The lower end of the stability field of amphibole was reached at 650 °C in the Mg-Fe binary. In the Mg system, Mg, Na and Si concentrations have a positive and Al a negative correlation with increasing T. The increase in Si and decrease in Al suggests an increase in Tschermak substitution towards the higher-T tourmalines. In the Mg-Fe system, Na and the Mg/(Mg+Fe) ratios have a positive correlation and Al a negative correlation with increasing T. The chemical analysis of talc and amphibole allows us also to determine the elemental K_d values (e.g. for Mg and Fe) of tourmaline-talc and tourmaline-amphibole pairs at ≥600 °C, where grains large enough for EMPA analysis were produced.