Experimental investigation of orbicular tourmaline in granitic melts

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Multiple hypotheses have been proposed for the origin of orbicular tourmaline observed in natural granites, including their formation by silicate-borosilicate liquid immiscibility. Given the role of boron in the evolution of pegmatites, and highly evolved melts in general, the existence of borosilicate immiscible melts would be of key importance. Experimental work has demonstrated that immiscibility can occur in boron-bearing hydrous silicate melt systems, but the compositions in which this has been found are quite different from what is observed in nature.

To investigate the origins of orbicular tourmaline, and explore the existence of borosilicate melt immiscibility, we have systematically examined two natural granite compositions in experiments; one containing abundant orbicular tourmaline and the other devoid of these. These granites were studied at both 1-atmosphere dry and 1 kbar H_2O-saturated conditions. Boron was progressively added to the tourmaline-free granite up to 50 wt% B_2O_3, whereas for the orbicular-tourmaline bearing granite we homogenized a mixture of the orbicule and the host granite to have ~5 wt% B_2O_3. Dry 1-atm experiments were conducted in sealed quartz tubes in a box furnace. Water-saturated 1-kbar experiments were conducted in sealed gold capsules in a rapid-quench cold-seal pressure vessel. All experiments were first homogenized at 1200 °C (dry, 1 atm) or 900 °C (wet, 1 kbar), then cooled slowly over several days then maintained at a dwell temperature 400 to 600 °C for > 3 days, then quenched.

The 1-atm dry experiments did not produce liquid immiscibility, even for B-contents well above those typically found in nature, in agreement with previous work. Water-saturated 1-kbar experiments show ~100-µm orbicules with symplectitic ~2-µm intergrowths of quartz and tourmaline, coexisting with fluid, glass, cordierite, and biotite. Rather than formation from a borosilicate melt, we interpret the symplectitic formation of tourmaline and quartz to accommodate the formation of low-SiO_2 tourmaline from a high-SiO_2 melt.