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Direct observation of immiscibility in pyrope-almandine-grossular garnet

LIPING WANG,* ERIC J. ESSENE, AND YOUXUE ZHANG

Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan 48109-1063, U.S.A.

ABSTRACT

Although recent thermodynamic models predict a low-temperature miscibility gap in the pyrope-almandine-grossular garnet solid-solution series, coexistence of two immiscible garnets consistent with the calculated miscibility gap has not been demonstrated previously. Here we report the discovery of such a coexistence in nature, which provides direct evidence for immiscibility in the pyrope-almandine-grossular system. Garnet inclusions were found near solidified fluid/melt inclusions in a single pyrope crystal collected from the ultramafic diatreme at Garnet Ridge, Arizona. Microprobe analyses close to the contact between the pyrope host and one garnet inclusion yield formulae of $(Mg_{1.98}Ca_{0.52}Fe_{0.50}Mn_{0.02})(Al_{1.89}Cr_{0.09})Si_3O_{12}$ for the host and $(Mg_{1.28}Ca_{1.31}Fe_{0.41}Mn_{0.02})(Al_{1.93}Cr_{0.07})Si_3O_{12}$ for the inclusion. High-resolution analytical traverses across the two-garnet boundary reveal that the compositional difference between the inclusion and the host increases as the contact is approached, implying that the two garnet grains represent an immiscible pair rather than a disequilibrium coexistence. The compositions of the coexisting garnets are in good agreement with those predicted from recent thermodynamic mixing models for pyrope-almandine-grossular garnet.