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In situ LA-ICP-MS analyses of skarn garnets: insights into metasomatic processes and implications for Lu/Hf geochronology

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Most metamorphic and magmatic garnets are known to fractionate REE, with generally HREE-enriched patterns, and high Lu/Hf and Sm/Nd ratios. These garnets are typically Al-rich but relatively little is known about garnets with more andraditic compositions. Here we present LA-ICP-MS data on garnets from the Crown Jewel Au-skarn deposit, USA, which range in composition from Adr30Gr70 to almost pure andradite (Adr>99). All garnets are extremely depleted in large ion lithophile elements (LILE), Ta, Hf, and Th, but Al-rich garnets are relatively enriched in Y, Zr, and Sc. A positive correlation exists between SumREE3+ and Al content, with Al-rich garnets showing "typical" HREE-enriched and LREE-depleted patterns, and weak positive or negative Eu anomalies. On the other hand, Fe-rich garnets (Adr>90) have much lower SumREE and exhibit LREE-enriched and HREE-depleted patterns, with a strong positive Eu anomaly. These REE patterns are partially explained by garnet crystal chemistry, with thermodynamic data suggesting preferential incorporation of HREE in grossular and LREE in andradite. Textural evidence, optical characteristics, and major and trace element geochemistry, show that variations observed in the Crown Jewel garnets are largely controlled by external factors. The data are consistent with Al-rich garnets being formed by diffusive metasomatism, under low W/R ratios, and in equilibrium with metasomatic fluids whose composition is locally buffered by the host rocks. Fe-rich garnets grow rapidly by advective metasomatism, under relatively high W/R ratios, and in equilibrium with a magmatic-derived fluid. Physical separation of high Lu/Hf Al-rich garnets from low Lu/Hf Fe-rich garnets is crucial to achieve robust garnet-whole rock isochrones.