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Factors controlling the crystal morphology and chemistry of garnet in skarn deposits: A case study from the Cuihongshan polymetallic deposit, Lesser Xing'an Range, NE China

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Abstract

The grossular-andradite solid solutions in garnet from skarn deposits in relation to hydrothermal processes and physicochemical conditions of ore formation remain controversial. Here we investigate garnet occurring in association with calcic and magnesian skarn rocks in the Cuihongshan polymetallic skarn deposit of NE China. The calcic skarn rocks contain three types of garnets. (1) Prograde type I Al-rich anisotropic garnets display polysynthetic twinning and a compositional range of $Grs_{18–80}Adr_{10–75}$. This type of garnet shows markedly low rare earth element (REE) contents (3.27–78.26 ppm) and is strongly depleted in light rare earth elements (LREE, 0.57–44.65 ppm) relative to heavy rare earth elements (HREE, 2.31–59.19 ppm). They also display a significantly negative Eu anomaly (Eu/Eu* of 0.03–0.90). (2) Fe-rich retrograde type II garnets are anisotropic with oscillatory zoning and own wide compositional variations ($Grs_{1–47}Adr_{30–95}$) with flat REE (13.73–377.08 ppm) patterns. (3) Fe-rich retrograde type III isotropic garnets display oscillatory zoning and morphological transition from planar dodecahedral {110} crystal faces to {211} crystal faces in the margin. Types III garnets exhibit relatively narrow compositional variations of $Grs_{0.1–12}Adr_{85–97}$ with LREE-enrichment (0.80–51.87 ppm), flat HREE patterns (0.15–2.46 ppm) and strong positive Eu anomalies (Eu/Eu* of 0.93–27.07 with almost all >1). The magnesian skarn rocks contain euhedral isotropic type IV Mn-rich garnet veins with a composition of $Grs_{10–23}Sps_{48–62}Alm_{14–29}$. All calcic garnets contain considerable Sn and W contents. Type II garnet containing intermediate compositions of andradite and grossular shows the highest Sn contents (64.36–2778.92 ppm), albeit the lowest W range (1.11–468.44 ppm). Birefringence of garnet is probably caused by strain from lattice mismatch at a twinning boundary or ion substitution near intermediate compositions of grossular-andradite. The fine-scale, sharp, and straight garnet zones are probably caused by self-organization, but the compositional variations of zones from core to rim are probably caused by external factors. The zoning is likely driven by external factors such as composition of the hydrothermal fluid. REE concentrations are probably influenced by the relative proportion and temperature of the system. Moreover, the LREE-HREE fractionation of garnet can be attributed to relative compositions of grossular-andradite system. The W and Sn concentrations in garnet can be used as indicators for the exploration of W-Sn skarn deposits.

Keywords: Garnet, birefringence, substitution of REE, skarn, Cuihongshan polymetallic deposit