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Deciphering the origin of low-grade W mineralization and hydrothermal fluids in the oxidized Fujiashan W skarn deposit using garnet geochemistry

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Abstract

Tungsten-bearing garnet is an important reservoir of W in oxidized W skarns. However, the degree to which W is remobilized from garnet into scheelite is unknown. In addition, differences between W skarns and Cu and Pb-Zn skarn fluids are poorly characterized. This study focuses on these issues and presents new backscattered electron (BSE) imaging, in situ major element, trace element concentration, and O isotope data for four types of garnets with different spatial locations and textures from the oxidized Fujiashan W skarn deposit. The Fujiashan garnets have Al-depleted cores and Al-enriched rims, reflecting temporal changes in fluid chemistry. In addition, garnet from proximal skarn areas is depleted in grossular (Grs = 2) and F (up to 0.10 wt%) in comparison to distal skarn garnet, which is enriched in grossular (Grs = 69) and F (up to 1.41 wt%). These spatial variations imply that F may have played a role in transporting Al to the distal parts of the skarns. Fujiashan andradite (Adr = 95) contains variable W (7.4–1780 ppm), indicating that the incorporation of W into garnet is controlled not just by Fe^{3+} abundance but also the availability of W in ore-forming fluids, dynamic external factors, and the concentration of Ti in garnet. Fujiashan garnet also contains relatively high W concentrations (up to 2221 ppm) and lacks evidence of re-equilibration during retrograde alteration. These relationships suggest that W-rich garnet is not the source for scheelite, potentially explaining the typical low W grades of oxidized W skarn deposits. In situ O isotopic values for Fujiashan garnet range from 4.2 to 7.4‰, indicating that the garnet formed from a mixture of magmatic and metamorphic fluids, with a limited contribution from meteoric fluids. These fluid characteristics contrast with the significant meteoric water contribution recorded by garnet in Cu and Pb-Zn skarn systems, suggesting significant differences between these skarn systems and the processes involved in the generation of W skarn mineralization.

Keywords: Garnet, skarn, in-situ O isotopic analysis, W mineralization