

Identification of Causative Intrusions of Skarns

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Skarn districts typically have multiple intrusions, similar to porphyry districts. For the exploration and understanding of skarns and related deposits, it is important to identify the causative/syn-skarn intrusion(s) and other intrusions' timing relationship with a skarn (pre-, late-, and post-skarn). If an intrusion contains only low-temperature alteration and mineralization assemblages (e.g., quartz-carbonate-sulfides), it is likely a pre-skarn intrusion. For the identification of syn-skarn intrusions, the reliable criteria include skarn zoning patterns in exoskarns, and high-temperature alterations in the intrusions, including red garnet-bearing endoskarn at the intrusion margin, and early-stage high-temperature porphyry-style veins (e.g., UST veins, EDM veins, A-, AB-, and B-veins with secondary biotite and/or K-feldspar haloes) inside the intrusion. If the intrusion is a narrow dike or sill, only endoskarn may occur. Where the intrusion directly contacts siliciclastic layers in a carbonate-siliciclastic package, only early-stage high-temperature porphyry veins may occur. Geochronology and Pb isotopes of intrusions and skarns can reject a genetic relationship if they are statistically different (95% confidence ranges do not overlap), but similarity (95% confidence ranges overlap) does not guarantee a genetic link. For geochronology, this is mainly because the dating uncertainties (typically 1% or higher for LA-ICP-MS and SHRIMP U-Pb dating) are typically larger than the time needed to form a skarn (e.g., <0.04 myrs at OK Tedi, Papua New Guinea). The spatial closeness to the skarn is not a reliable criterion, because the contact zone between an older intrusion and dirty limestones could be a favorable location for younger skarns due to secondary permeability generated during contact metamorphism of the older intrusion. A causative intrusion may still be at depth (e.g., Big Gossan, Indonesia) and unexposed. Late-skarn intrusion may contain inclusions of earlier skarn, plus narrow/sparse high-temperature red garnet endoskarn and/or early-stage porphyry veins. Post-skarn intrusions have none to little alteration.