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The composition of garnet in granite and pegmatite from the Gangdese orogen in southeastern Tibet: Constraints on pegmatite petrogenesis

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Abstract

Two generations of garnet are recognized in a granite and a pegmatite from the Gangdese orogen in southeastern Tibet on the basis of a combined study of petrography, major and trace element profiles, and garnet O isotopes. Zircon U-Pb dating and Hf-O isotope compositions also help constrain the origin of both granite and pegmatite. The first generation of garnet (Grt-I) occurs as residues in the center of garnet grains, and it represents an early stage of nucleation related to magmatic-hydrothermal fluids. Grt-I is dark in backscattered electron (BSE) images, rich in spessartine, and poor in almandine and grossular. Its chondrite-normalized rare earth element (REE) patterns show obvious negative Eu anomalies and depletion in heavy REE (HREE) relative to middle REE (MREE). The second generation of pegmatite garnet (Grt-II) occurs as rims of euhedral garnets or as patches in Grt-I domains of the pegmatite, and it crystallized after dissolution of the preexisting pegmatite garnet (Grt-I domains) in the presence of the granitic magma. Compared with Grt-I, Grt-II is bright in BSE images, poor in spessartine, and rich in almandine and grossular contents. Its chondrite-normalized REE patterns exhibit obvious negative Eu anomalies but enrichment in HREE relative to MREE. The elevation of grossular and HREE contents for Grt-II relative to Grt-I domains indicate that the granitic magma had higher contents of Ca than the magmatic-hydrothermal fluids. The garnets in the granite, from core to rim, display homogenous profiles in their spessartine, almandine, and pyrope contents but increasing grossular and decreasing REE contents. They are typical of magmatic garnets that crystallized from the granitic magma. Ti-in-zircon temperatures demonstrate that the granite and pegmatite may share the similar temperatures for their crystallization. Grt-II domains in the pegmatite garnet have the same major and trace element compositions as the granite garnet, suggesting that the pegmatite Grt-II domains crystallized from the same granitic magma. Therefore, the pegmatite crystallized at first from early magmatic-hydrothermal fluids, producing small amounts of Grt-I, and the fluids then mixed with the surrounding granitic magma. The U-Pb dating and Hf-O isotope analyses of zircons from the granite and pegmatite yield almost the same U-Pb ages of 77–79 Ma, positive $\varepsilon_{Hf}(t)$ values of 5.6 to 11.9, and $\delta^{18}O$ values of 5.2 to 7.1‰. These data indicate that the granite and pegmatite were both derived from reworking of the juvenile crust in the newly accreted continental margin prior to the continental collision in the Cenozoic.

Keywords: Hydrothermal garnet, magmatic garnet, pegmatite, dissolution-reprecipitation