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Crystal-size distributions of garnets in metapelites from the northeastern Bushveld contact aureole, South Africa

YASUNARI KANEKO,[1,*] TOSHIAKI TSUNOGAE,[2,†] AND TAKASHI MIYANO[3,‡]

[1]Doctoral Programs in Geosciences, the University of Tsukuba, Ibaraki 305-8571, Japan
[2]Graduate School of Life and Environmental Sciences (Earth Evolution Sciences), the University of Tsukuba, Ibaraki 305-8572, Japan
[3]Institute of Geoscience, the University of Tsukuba, Ibaraki 305-8571, Japan

ABSTRACT

Crystal size distributions (CSDs) provide information about the nucleation and growth conditions of crystals. In the present study, we investigated CSDs of garnets in metapelites in the Bushveld contact aureole to examine the mechanisms of garnet nucleation and growth and to deduce controlling factors of CSDs. The CSD shapes were evaluated in terms of the Law of Proportionate Effects crystal growth and of the thermally accelerated, diffusion-controlled nucleation and growth. We adopted both the non-parametric and parametric stereological methods to estimate three-dimensional crystal size distributions from two-dimensional measurements of crystal diameters. The studied garnets showed various CSD shapes: asymptotic, lognormal, and near-symmetric distributions. These varieties of CSDs are generally controlled by heating rate, metamorphic temperature, and duration of thermal effects due to the intrusion of the igneous body, the Rustenburg Layered Suites. The chemical composition of the host sedimentary rocks is an additional important factor in controlling CSD shapes: it affects garnet growth as a supply source of nutrients for the mineral. At the contact between the Rustenburg igneous rocks and the aureole, where a rapid increase of temperature and a migmatitic extraction of siliceous melts occurred, the CSD is asymptotic showing constant- or accelerating-nucleation rates. In contrast, at some distance from the igneous contact where a relatively slower rise of temperature occurred and lognormal to near symmetric CSDs were mainly generated, suggesting decaying-rate nucleation dominated. However, even in such thermal conditions, differences in chemical compositions of host rocks affected growth mechanisms of garnet porphyroblasts, which resulted in relatively symmetric and pseudo-lognormal CSDs of garnets in biotite- and quartz-rich layers, respectively, in a pelitic sample.