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Charge contrast imaging of fine-scale microstructure and compositional variation in garnet using the environmental scanning electron microscope

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ABSTRACT

Gaseous secondary electron (GSE) imaging of eclogite garnets under the environmental scanning electron microscope (ESEM) at low chamber gas pressures reveals detailed image contrast patterns (charge-contrast images, CCI) that are not present in back-scattered or secondary electron images. Image intensity is a function of the amount of surface charge accumulation. Successful acquisition of CCI depends on frame size and beam scan rate at a given chamber gas pressure and beam current. Images are obtained in a few seconds, and are stable and reproducible. CCI patterns do not correlate with cracks or grain boundaries, but do correspond closely to variations in major-element composition, both in the form of concentric (growth) zoning, and branching, linear features interpreted as cracks that have been healed by new garnet growth. Causes of CCI are not yet well understood, but may be related to variations in lattice defect density and their influence on charge-trapping and dissipation. These in turn influence the rate of charge build-up at or very close to the specimen surface. One interesting possibility is that CCI images detect vacancies related to non-homovalent coupled substitutions involving, for example, REE and hydroxyl, so the method offers a way of imaging the distribution of these trace species in garnets. The CCI images are rich in microstructural detail and offer the potential for rapid, high-resolution, low-noise reconnaissance mapping of intragranular microstructure and compositional variation in both natural and synthetic garnets.