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DOI: 10.1017/S1431927606066918
Microsc Microanal 12(Supp 2), 2006

SEM Cathodoluminescence Imaging of Quartz Phenoclasts in the Nepisiguit Falls Formation, Bathurst Mining Camp: Evidence of Explosive Fragmentation

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Cathodoluminescence (CL) is a technique commonly employed in the geosciences in order to reveal internal structures, growth zoning and lattice defects of a variety of mineral specimens (feldspars, carbonate minerals, etc.) [1]. The conventional optical CL technique images photons emitted when a sample is irradiated by an electron beam. This type of CL works well for many minerals, but can only distinguish between detrital and non-detrital quartz grains. However, when used in conjunction with the scanning electron microscope (SEM), it can reveal internal structures, growth zoning, and lattice defect features in minerals that exhibit weak luminescence, i.e., in quartz grains such features are not discernable by other analytical techniques. In quartz, variations in luminescence intensity may result from trace elements present in the grain structure or from the ordering degree of the quartz lattice. These variations are a reflection of the P-T-t-x conditions in which the quartz grains formed such that high-temperature volcanogenic quartz grains usually exhibit little zoning in the blue spectrum and low-temperature metamorphic quartz grains may exhibit complex zoning in the red spectrum.

Preliminary examination of quartz phenoclasts from the felsic tuffaceous rocks of the Nepisiguit Falls Formation, NB and tuffisites from the Mt. Pleasant, NB area was performed using the JEOL JSM-5900LV SEM operating at an accelerating voltage of 15 kV and fitted with a Gatan MonoCL3 detector. Figure 1 is a pan-CL image (integrated image of all visible wavelengths) showing that weak zoning is present in some quartz phenoclasts from the Nepisiguit Falls Formation, whereas strong zoning is present in the quartz phenoclasts from the Mt. Pleasant tuffisites as shown in Fig. 2. Zoning in quartz grains is related to grain boundary diffusion and the increased frequency of zoning suggests that the quartz phenoclasts grew rapidly thereby enriching the immediate boundary zone in non-compatible elements that become incorporated in to the grains causing lattice defects. This relationship suggests that the Nepisiguit Falls Formation quartz phenoclasts grew slowly allowing for equilibrium of the melt in the grain boundary region, whereas the Mt. Pleasant tuffisite quartz phenoclasts grew rapidly allowing for more substitution of non-compatible elements into the crystal structure. In addition, the observed zoning pattern does not correspond with the phenoclast grain boundaries suggesting these grains may have been explosively fragmented.

Highly embayed quartz is present in both the Nepisiguit Falls Formation felsic tuffaceous rocks and the Mt. Peasant tuffisite. The Nepisiguit Falls Formation quartz phenoclasts shows no zonation (Fig. 3) suggesting only one phase of quartz crystallization in the magma chamber prior to eruption. Petrographic examination of these highly embayed phenoclasts shows that they have sharp boundaries though they were not explosively fragmented. If explosive fragmentation had occurred in these phenoclasts, it would be expected that fragmentation would obliterate the embayments breaking the phenoclast into smaller fragments. In addition, these embayments were preserved during ascent in the conduit indicating the system did not behave as a two-phase gas-pyroclast system, but rather as a one-phase mixture. The Mt. Pleasant tuffisite also contains similar highly embayed quartz phenoclasts (Fig. 4), suggesting a similar eruptive history. However, the well zoned nature of these grains suggests that a bubble formed which expanded as the system depressurized as the grain grew.

References

[1] M. Pagel et al., Cathodoluminescence in Geosciences, Springer Verlag, Berlin, 2000.
[2] This work was supported by the Natural Sciences and Engineering Research Council of Canada.

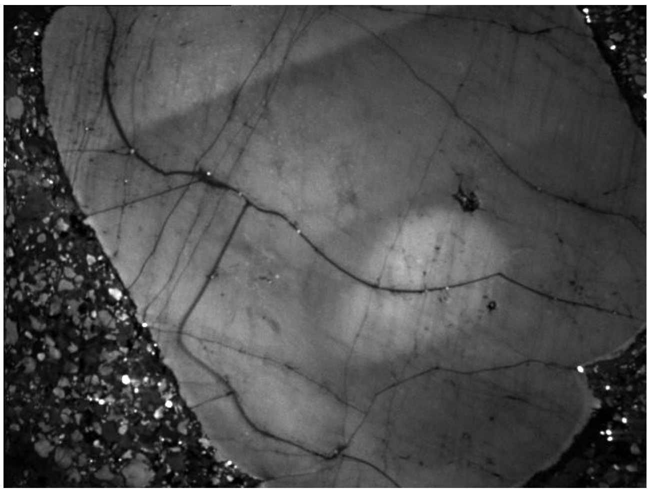

Fig. 1. Weak zoning in quartz phenoclasts from the Nepisiguit Falls Formation felsic tuffaceous rocks.

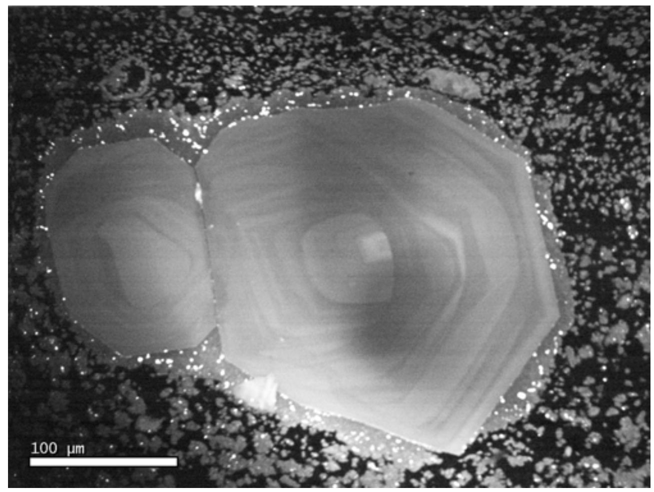

Fig. 2. Strong zoning in quartz phenoclasts from the Mt. Pleasant tuffisite.

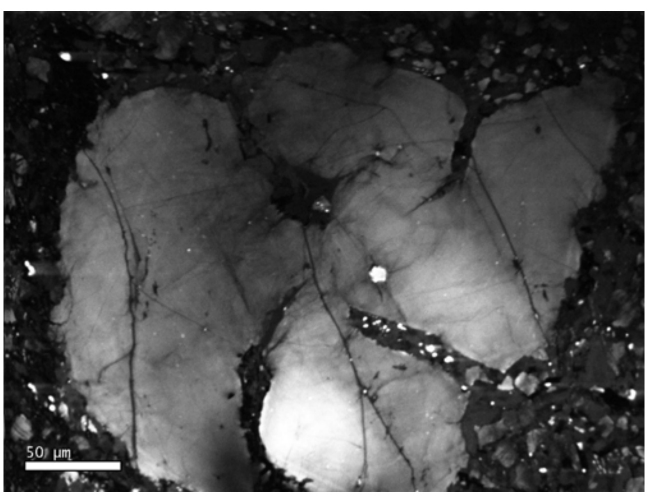

Fig. 3. Highly embayed quartz phenoclasts from the Nepisiguit Falls Formation showing no relationship between zoning and embayment formation.

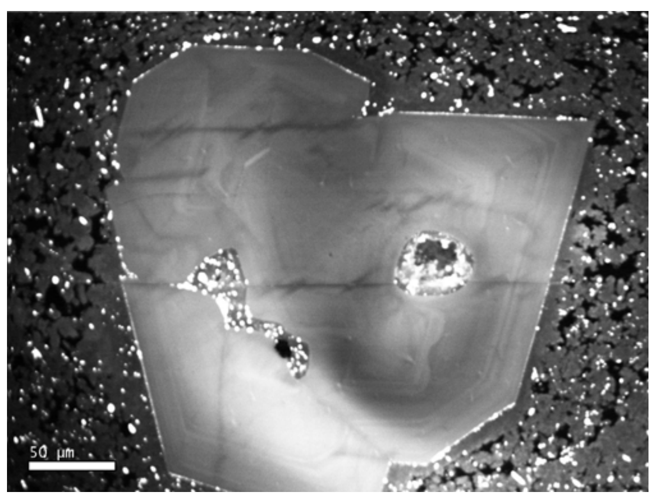

Fig. 4. Strong zoning in quartz phenoclasts from the Mt. Pleasant tuffisite showing embayments. The cross-cut zoning is a result of bubble growth due to depressurization.

https://doi.org/10.1017/S1431927606066918 Published online by Cambridge University Press