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Statistical characteristics and origin of oscillatory zoning in crystals

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Abstract

Complex intracrystalline zoning patterns in hydrothermal garnet and vesuvianite and magmatic plagioclase were analyzed by statistical methods to test for fractal behavior. The zoning data were collected by electron and proton microprobe, and backscattered electron images and polarized micrographs were digitized. The analysis shows that self-affine fractal geometry can be used to characterize the zoning patterns of vesuvianite and some garnet patterns. The range of power-law scaling extended up to two decades. The results from the plagioclase samples were not sufficient to determine whether or not the zoning patterns were self-affine. The measured Hurst exponents are mostly in the range 0.25–0.45, indicating fractal scaling and anti-persistent behavior. This means that an increasing compositional trend in the past favors a decreasing trend in the future and vice versa. No distinct periodic components of the zoning patterns were found.

The influence of environmental changes (external fluctuations) on a simple crystal growth model was investigated by numerical simulations. The concentration at the boundary of a diffusion layer was allowed to vary as a Brownian-motion curve, and the effect of the external fluctuation on diffusion and local growth kinetics was investigated. We conclude that factors operating on scales much larger than the local interface processes are most important in controlling the zonation.