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Pressure-controlled formation of asymmetric chemical zoning in garnet

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Chemical zoning in garnet reflects variations in pressure (P) and temperature (T) along the path which the rock experienced. Such a zoning can be preserved in situations where diffusional homogenization and metasomatism is absent. Traditional inverse growth zoning models can only predict and explain symmetrical zoning. However, asymmetrical zoning is often observed in nature as well. In this contribution, we therefore focus on a prograde asymmetrical zoning in garnets that happens under fluid saturated conditions. In such examples, it is assumed that the surrounding fluid homogenizes its chemical composition rapidly and that it is in chemical equilibrium with rims of adjacent minerals. Therefore, a possibility of zoning caused by a local fluid chemical heterogeneity is ruled out. However, it has been proved that fluid pressure varies along the grain boundaries, in particular, during pressure solution processes. Hence, the asymmetrical zoning may be controlled by the variations in fluid pressure if the local equilibrium is satisfied. In this study, the influence of fluid pressure variation on chemical zoning is investigated using thermodynamic calculation with Perple_X implemented into a Matlab script to simulate the formation of asymmetrical chemical zoning caused by different pressure gradient along the grain boundaries. The possibility of comparing the thermodynamic calculation with numerical simulation is feasible, as the process of brute-force computational method using Perple_X can be segmented taking into account the varying pressure. In contrast to the traditional point of view of the prograde growth zoning in garnet, it is proved that grain scale fluid pressure variation, even on the order of 0.1 GPa, can be a reason for the development of the asymmetric zoning. Future work will focus on the relation between grain scale chemistry and mechanics using numerical and analytical techniques.

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