Contrasting mechanisms for two pulses of garnet growth at Stillup Tal, Tauern Window, Austria

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Growth of ca. 110 cm³ sub-spherical garnet crystals in a shear zone in the Austrian Tauern Window required ca. 7.5 Myrs, with the vast majority of this growth occurring in two distinct pulses [1]. These pulses are characterised by growth rates at least 5 times higher than the ‘ambient’ rate experienced during the ca. 2 Myr inter-pulse hiatus, and during the final stages of crystal growth. Here we explore possible mechanisms for such short crystal growth bursts, testing their viability in terms of an Alpine history, and using the available constraints to calibrate an exhumation velocity.

The first growth pulse occurred early in the preserved garnet history (inner 2 cm diameter of the crystal core) and is well resolved to no more than a few hundred thousand years duration (likely much less). A thermodynamically constrained garnet growth model [2] and a complex suite of mineral inclusions suggest that this records growth over a relatively limited range of P and T, at > 35 km depth and temperatures several 10s of degrees above the garnet-in reaction. A sharp Mn decrease within this growth phase likely reflects Rayleigh fractionation, but otherwise both garnet composition and its mineral inclusion assemblage are effectively constant. This supports the hypothesis that a kinetic trigger initiated and accelerated garnet growth at this time, with a distinct network of radiating fluid inclusions (absent outside the crystal core) attesting to fluid abundance [1].

A second phase of accelerated growth is more poorly resolved to no more than 1.5 million years (again, probably much less). Characteristic changes in all measured divalent cations imply that both this rapid crystal overgrowth and the slowly-grown crystal segment that preceeded it grew during ca. 5 kbars decompression and 50-100°C heating. Results are consistent with equilibrium growth along a P-T trajectory that traversed fields of relatively constant mineral assemblage and then intersected a set of mineral reactions that accelerated garnet growth. Both slow garnet growth after the first pulse and rapid growth in the second pulse are thus possible without recourse to additional kinetic mechanisms or substantial increases in heating or decompression rate.