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Progressive shape evolution of a mineral inclusion under differential stress at high temperature

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Interfacial tension (g) and differential stress (s) affect the shape of a mineral grain included within a crystalline host. We present a simple model that predicts the progressive change in aspect ratio of an ellipsoidal inclusion. Three processes are considered in the model: dislocation creep, interface diffusion creep, and rounding by interface diffusion. The model reveals that (1) the inclusion aspect ratio (L) evolves toward a steady state value, (2) the time taken to achieve a steady state aspect ratio increases with increasing grain size (R), and (3) the dominant deformation mechanism varies from diffusion creep to dislocation creep with increasing grain size and/or differential stress.

The L-R distribution pattern of garnets in a granulite-facies quartzite from the Lu tzow-Holm Complex, East Antarctica is compared with the model result. The garnet aspect ratio systematically varies with respect to grain size, and the most elongate ones are of intermediate grain size (0.25 mm). A two-stage deformation with high and low differential stresses (stage A and B) best explains for the observed L-R pattern of garnets. The duration (tA) at stage A is determined only when the differential stress (sA) is assumed due to the size independency of dislocation creep. Assuming ggrtqtz = 1.0 N m 1, Dgb,A =1.0x10-12 m2/s, Dgb,B = 1.0 x 10-11 m2/s, and sA = 1.0 MPa, the garnet data are fitted to a theoretical curve under condition of sB = 1.4 x 10-2 MPa, tA = 0.5 Myr, and tB = 14.4 Myr.