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石英岩の格子定向配列に及ぼす動的再結晶の役割
Role of dynamic recrystallization in lattice preferred orientation of quartz rocks

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From the microstructural analysis of plastically deformed rocks, the c-axis lattice preferred orientation (LPO) of quartz has been utilized to infer deformation conditions: sense of shear, deformation temperature, and/or water content. The c-axis LPO patterns change from type I crossed-girdle at lower temperature to point maxima at Y axis of strain ellipsoid (Y max LPO) at intermediate temperature, to point maximum at X axis (X max LPO) at higher temperature. The change in LPO patterns is known to reflect the change in the dominant slip systems of quartz from basal <a> and rhomb <a> slip, to mainly prism <a> slip, to prism [c] slip with deformation temperature (Stipp et al., 2002). Most naturally deformed rocks with a strong LPO are dynamically recrystallized. It is not clear whether the LPO patterns are controlled only by the dominant slip systems or by dynamic recrystallization processes such as grain boundary migration and subgrain rotation. Recent experiments have clarified the formation of Y max LPO patterns with increasing strains and degree of dynamic recrystallization where grain boundary migration is the dominant mechanisms of dynamic recrystallization (Heilbronner and Tullis, 2006; Muto et al., 2011). However, the effect of other mechanisms occurring under lower temperature conditions has been not clear yet. In order to clarify how dynamic recrystallization affects the LPO development under lower temperature than previous experiments, we conducted general shear experiments in a Griggs apparatus using single crystals of synthetic quartz. We utilized three different initial orientations to activate three dominant slip systems of quartz: basal <a>, prism <a> and prism [c] slip. The c-axes of samples with initial orientations for basal <a> slip system and prism [c] slip system progressively rotated with the sense of shear with strains. The amount of the rotation at a given strain is larger in the samples with prism [c] initial orientation than those of basal <a> initial orientation, implying the rapid consumption of the harder slip system. The c-axis of samples in the basal <a> initial orientation rotated 90 degrees to prism [c] orientation at gamma of 2 and further to the orientation suitable for basal <a> slip. The samples of the prism [c] initial orientation rotated 90 degrees to orientation suitable for basal a slip and completely recrystallized at gamma ˜ 6. Recrystallized grains show symmetric broad single maximum at the Z axis of the strain ellipsoid, consistent with the c-axis LPO of recrystallized grains (Heilbronner and Tullis, 2002) where bulging is the dominant recrystallization mechanism. On the other hand, the samples with prism <a> initial orientations did not show any recrystallization up to strains as high as gamma of 7 and kept its c-axis orientation located at the Y axis of the strain ellipsoid. This indicates that grains in basal <a> and prism [c] initial orientations were recrystallized to activate easy basal <a> slip with progressive deformation. On the other hand, the grains with prism <a> initial orientation do not change their c-axis orientations with progressive shear. Therefore, the activation of easy basal <a> slip and additional prism <a> and/or rhomb <a> slip to satisfy von Mises criterion results in the development of type-I crossed or inclined single girdle depending on the deformation geometry. With increasing deformation temperature to higher greenschist to amphibole facies conditions where rapid grain boundary migration can occur, grains oriented for weak prism <a> slip can grow at the expense of grains in other orientations, results in development of Y max LPO with dynamic recrystallization (Heilbronner and Tullis, 2006; Muto et al., 2011). Therefore, the LPO transition observed in natural deformed rocks from type I crossed or single girdle to Y max LPO may basically reflect the change in dominant mechanisms of dynamic recrystallization with temperature.

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