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Microstructural development of quartz aggregate: an experimental study on agate

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Deformation experiments have been carried out to investigate the effect of primary crystallographic preferred orientation (CPO) in quartz aggregates on microstructural development. Cylindrical samples of natural agates were axially deformed in a Kumazawa solid medium deformation apparatus in different crystallographic orientations with compression direction. The experiments were performed at temperatures of 700-800C, confining pressure of 400-600MPa, a strain rate of 1.0x10-6˜2.4x10-5 /s and to bulk finite strains of 0˜45%. The deformed samples were analyzed in detail using optical microscope and electron backscatter diffraction (EBSD).

Prism(c) slip system is active in quartz under high temperature condition, so that CPO of c-axes tends to show a girdled pattern normal to the shortening direction. Such patterns have been observed in deformed agates, which primary CPO patterns were inclined from horizontal direction by about 20. However, deformed agates, which primary CPO patterns have a girdle pattern sub parallel to the shortening direction, showed that c-axes occurred parallel to the shortening axis. Furthermore, their grain sizes are remarkably coarser than the other grains. These CPO patterns could have formed in the selective grain growth due to grain boundary migration in relation to the Schmidt factor. Grains that have large Schmidt factors are large can be deformed easily so that they would have high dislocation densities. In contrast, grains which c-axis are parallel to the compression direction are hard to be deformed, because their Schmidt factors are small so that they have the most unsuited crystallographic directions for the slip system. These hard grains would have low dislocation densities. Subsequently, the hard grains grow selectively because of differences of dislocation densities. As a result, deformed samples have two concentrations: one is the horizontal direction; the other is the direction parallel to the compression direction.

Such examples have been reported in natural rocks deformed under high temperature of 600C or more that is necessary to activate prism(c) slip system. Furthermore, the existence of water has been reported to activate prism(c) slip system and to make grain boundary migration be faster. This suggests that the selective grain growth by the grain boundary migration could occur even at lower temperature conditions.