Deformation experiments on natural limestone with a Griggs apparatus and development of lattice preferred orientation

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We have started to conduct deformation experiments on rocks with a modified Griggs-type apparatus, which was introduced in March, 2000 at Hiroshima university, and we had conducted preliminary experiments with this for three years. Last year, we conducted deformation experiments on naturally deformed limestone at 300 C from the Northern Chichibu belt, which has a strong CPO. One problem of this apparatus is a large frictional force, which is generated between a sample cell and a moving micropiston. Due to the frictional force, the axial force continues to increase during constant displacement experiments (frictional stresses up to 5 kb are generated at 40 % shortening), and a hit point between a sample and alumina piston, where the axial force start to increase greatly due to the elastic deformation, is not observed at all in the axial force versus displacement curve.

Since the hit point is not observed at all during constant displacement experiments, we control the total strain of samples by calculating the time which passes from the beginning of experiments to the hit point, based on the measured amount of shortening of retrieved samples. We have conducted axisymmetric shortening experiments of 10%, 20% and 40% at temperature conditions of 100, 200, 400 and 600 C. The displacement rate of micropiston is 1 mm/hour, corresponding to the shortening rate of 6*10-5/s for the samples of 5 mm height. The confining pressure is ca. 10 kb.

In limestone samples before experiments, a strong low-T type CPO develops, where the c-axes of calcite polycrystals are strongly preferentially oriented parallel to the direction perpendicular to the foliation (the sample Z-axis), and a-axes parallel to the lineation direction (the sample X-axis). In these experiments, the limestones are rather shortened in the direction parallel to the X-axis, and we analyze how the existent CPO is modified during experiments. The measurements of CPOs have been carried out at the laboratory of Kanagawa at Chiba University, using an EBSP facility.

Results: In all of experimentally deformed samples of 40% shortening at any temperature, the existent CPO is completely erased, and strong new CPOs conforming to the experimental stress framework develop. Even in samples of 10-20% shortening, the new CPOs are clear, although the old CPOs remain. In the samples of 40% shortening at 100 and 200 C, the c-axes are preferentially oriented parallel to the shortening axis (Z-maximum), while those at 400 and 600 C, they are oriented at 30 degrees from it (split maxima). Both the fabric transiton and its temperature conditions can be correlated with the existent experimental data (e.g. Wenk et al., 1981). According to Takeshita et al. (1987), the Z-maximum c-axis fabric is caused by dominant activation of e-twin and r-slip, while the split maxima are caused by dominant activation of these systems plus f-slip.

Although the experiments are conducted in axisymmetric compressional stress field, the XY section of deformed samples is more elongated parallel to the X-direction. This plastic anisotropy is caused by the existent CPO, where the c-axes are preferentially oriented parallel to the X-axis of the experiments (the sample Z-axis). Therefore, the e-twin and r-slip slip plane are favorably oriented for the activation in the stress field of the experiments. The orthorhombic symmetry of deformation geometry conforms to the fact that the experimental CPOs exhibit orthorhombic, not axial symmetry.