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An in-situ X-ray diffraction study on the high-pressure decomposition reaction of albite under differential stresses

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Introduction

In subducting oceanic crust, the gabbro-eclogite transformation is important because this transformation may change physical properties of the crust to the large density increase and perhaps low viscosity because of fine grain size of new phases. As the stress environment is influenced by the rate of transformation each other, it is important to understand the effects of deformation on the rate and mechanism of the transformation.

Decomposition of plagioclase is one of the principal reactions in the gabbro-eclogite transformation. In this study, we have carried out in-situ X-ray diffraction experiments on the high-pressure decomposition reaction from albite (one end menber of plagioclase) into jadeite and quartz or coesite under uniaxial differential stress.

Albite		Jadeite		Quartz or Coesite
$NaAlSi_3O_8$	$\rightarrow$	$NaAlSi_2O_6$	+	SiO_2

Experiments

The deformation experiments were conducted using multi-anvil type deformation apparatus (D-CAP) newly installed at BL-14C2 of Photon Factory. Polycrystalline starting material with about 10 micron grain size was prepared by annealing the natural albite powder at 2 GPa and 1353K for 2 hours. The starting materials were first compressed hydrostatically to about 1.4-1.9 GPa and heated to 673-973K in the stability field of high pressure phases. Specimens were annealed to reduce the grain interface strain at this condition for about 1 hour. Thereafter, uniaxial differential stress was applied to the sample with a fixed vertical ram speed. The transformation and deformation processes were observed by time-resolved two-dimensional X-ray diffraction (2DXRD) measurements every 20 minutes using monochromatic X-ray (50 keV) and imaging plate. 2DXRD patterns are used to obtain the transformed fraction and lattice strain of the sample. Plastic strain of the sample was measured from the X-ray radiography images. Differential stresses were calculated using the lattice strain equation showed by Singh et al., 1998[1].

Results

The strain rates applied to the samples were between 6.1×10^{-6} and 5.2×10^{-5} /s and maximum axial strain of sample amounted to about 30%. Maximum differential stress calculated from lattice strain of albite was 3.4 GPa.

Samples deformed below 773K showed no sign of transformation, while albite decomposed to jadeite and quartz during deformation above 873K. Reaction products consisting of sub micron fine grains were grown in an elongated lamellar structure perpendicular to the direction of the first principle stresses [Fig.2]. Detailed analysis is now in progress.

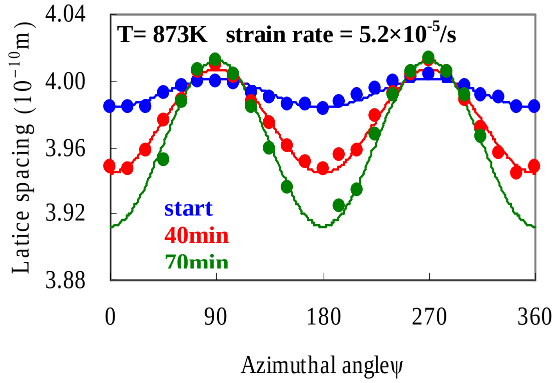

Fig.1 Dependence of lattice spacing of albite (-201) on azimuthal angle ψ under the differential stress during deforming experiment. 0° and 180° correspond to the direction of the first principle stress. Curved lines were calculated from using lattice strain equation [1]. Differential stress increased to a few GPa as deformation proceeded.

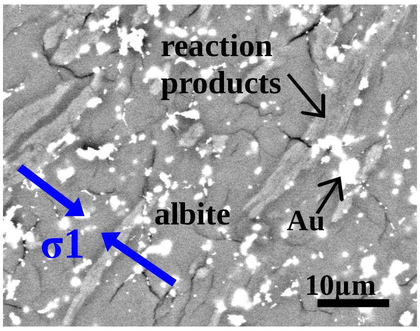

Fig.2 BSE image of the recovered sample. σ1 shows the direction of first principle stress.

References

[1] Singh et al., Journal of Applied Physics, 83, 7567-7574, (1998).

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