

## Kinetics of plagioclase breakdown at high pressure: Implications for gabbro-eclogite transformation in subducting oceanic crust

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### Introduction

The gabbro-eclogite transformation in subducting oceanic crust has important implications for dynamics of subduction, slab seismicity, and slab velocity structure because of the large density increase (about 15%) during this reaction. It has been suggested that the depth of this transformation depends not only on the equilibrium phase relations but also is greatly affected by reaction kinetics. However, a quantitative evaluation of the rates of eclogitisation is not yet possible because there have been few experimental studies of the kinetics of mineral reactions which commonly occur during this transformation. Microstructural observations of some partially-eclogitised rocks have revealed that eclogitisation of coarse-grained gabbro proceeds by two localized reactions; i.e., pseudomorphic breakdown of original minerals and corona formation between original grains. In the present study, we have examined reaction kinetics of pseudomorphic (isochemical) breakdown of plagioclase that is thought to be an important process for the density increase during eclogitisation.

### Experimental

Two kinds of starting material were used in this study, sodic (natural albite, Ab<sub>98.0</sub>An<sub>0.4</sub>Or<sub>1.6</sub>) and calcic (natural labradorite, Ab<sub>45.0</sub>An<sub>51.8</sub>Or<sub>3.2</sub>) plagioclases. High-pressure in-situ X-ray diffraction experiments were carried out using a multi-anvil press MAX-80 installed at KEK-PFAR. The powder of starting material was compressed at room temperature to about 1 GPa and annealed at 1173-1273K for 2 hours to achieve equilibrium microstructures, resulting in the grain size of about 20 microns. Following the annealing, kinetics of decomposition reaction of plagioclase have been observed by in-situ X-ray diffraction method at 2.2-3.6 GPa and 573-973K. Time-resolved X-ray diffraction data for these reactions were collected every 10-300 seconds. Transformation microstructures and water contents of recovered samples were investigated using SEM and FTIR, respectively.

### Results and discussion

The breakdown of sodic plagioclase (albite) to jadeite + quartz (coecite) occurred by grain-boundary nucleation and diffusion-controlled growth mechanisms. Preliminary results showed that the reaction proceeds rapidly under both hydrous (about 0.5 wt.% H<sub>2</sub>O) and nominally anhydrous conditions at relatively low temperatures of 673-773K and overpressures of more than 2 GPa from the equilibrium boundary. Extrapolations of obtained growth kinetics suggest that the breakdown of albite with the grain size of 5 mm can complete in 10000 years at 573K. We observed that the albite breakdown becomes very slow near the equilibrium boundary (overpressure of about 0.5 GPa) even at higher temperature of 923K probably due to difficulties of nucleation processes. On the other hand, we found large differences in the breakdown kinetics between sodic and calcic plagioclases. Decomposition of calcic plagioclase (labradorite) to jadeite + grossular + kyanite + quartz (coecite) was much slower than that of sodic plagioclase, which is almost identical to the effect associated with a 400-500K difference in temperature. This is probably because of the very complex reaction (dissociation into 4 phases) and the slow diffusion rate of Ca. Calcic plagioclase is a major constituent of gabbro in oceanic crust and its breakdown involves the large density increase (nearly 20%). Although further quantitative kinetic experiments are needed in the future, the breakdown kinetics of calcic plagioclase may have an important role for the density increase in oceanic crust during eclogitisation.