

# Mineralogical characterization of the carbonation-decarbonation system in the Archean plate tectonics

# Soichi Omori[1]

[1] Res. Centr. Evolving Earth and Planets, Tokyo Tech.

## Background:

In the present Earth, the crustal Urey cycle of CO<sub>2</sub> involving silicate weathering and carbonate deposition is believed to act as a dominant climate buffer in geological time scale (over 1 my). On the other hand, it is revealed that immature continent and lack of massive carbonate-rock body are characteristics of Archean Earth. Therefore the weathering-deposition CO<sub>2</sub> cycle did not work in the early Earth. Geological studies in the Archean greenstone belt have shown that plate tectonics had already started at 3.8Ga, and hydrothermal alteration at mid-oceanic ridge (MOR) had caused extensive carbonation in the oceanic crust. Hence, the MOR hydrothermal carbonation and subsequent subduction-zone metamorphism had an important role in the Archean carbon cycle.

## Aim and method:

The aim of the present study is to characterize carbonation-decarbonation processes in the Archean ocean floor and subduction zone, using phase-equilibrium petrology. Both subduction zone metamorphism and MOR hydrothermal carbonation are simulated by a thermodynamic forward modeling at various physicochemical conditions to discuss temporal changes of the CO<sub>2</sub> fluxes. Stability of carbonate minerals in the oceanic crust and hanging wall peridotite in the subduction zone is estimated including transfer of H<sub>2</sub>O-CO<sub>2</sub> fluid. Correlation between degree of hydrothermal carbonation and composition of the hydrothermal fluid is examined. Basic parameters for bulk rock-composition and physicochemical conditions of the hydrothermal process are taken from those of greenstones in the 3.5Ga North Pole area, Pilbara Craton, Australia (Kitajima, 2001).

## Subduction zone metamorphism:

In the North Pole area, carbonate-bearing mineral assemblage is restricted within upper 1 km from the bottom of bedded chert which represents ancient ocean floor. The mean modal abundance of carbonate mineral is roughly 30 vol% in the carbonated-zone. During the subduction-zone metamorphism along the Archean subduction-zone geotherm, such a carbonated oceanic crust releases H<sub>2</sub>O-CO<sub>2</sub> fluids with various XCO<sub>2</sub> to the wedge mantle, and the fluid reacts with hanging-wall peridotite to form another carbonate. Although the oceanic crust could not keep CO<sub>2</sub> as carbonate in the Archean high-T subduction, the carbonate was still stable in the peridotite. The peridotite could contain about 6 wt% of CO<sub>2</sub> as carbonate. On the assumption that the hanging-wall peridotite was dragged down to deep mantle with the subducting plate, the subduction flux of CO<sub>2</sub> into the deep mantle is estimated to be 1E12 kg/y.

## Hydrothermal carbonation:

A pressure condition of the hydrothermal carbonation of the oceanic crust at the MOR is estimated to be about 30 MPa, and the temperature of the hydrothermal fluid was 350 degC (Kitajima 2003). Amount of the carbonate depends on XCO<sub>2</sub> of the source hydrothermal fluid and rock/fluid ratio, at constant P-T condition. The amount of the carbonate changes discontinuously as a function of XCO<sub>2</sub>, because the stability of carbonate is constrained by discontinuous reactions. However, see in perspective, the amount of carbonate and XCO<sub>2</sub> in source hydrothermal fluid show almost linear correlation in a range of XCO<sub>2</sub> less than 0.1. Although relation between a oceanic XCO<sub>2</sub> and composition of hydrothermal fluid is not clear, yet, CO<sub>2</sub> decline in the ocean (e.g. by the subtraction to the mantle by the subduction) must have reduced the degree of carbonation in the oceanic crust, presumably in linear correlation. Therefore, this process possibly acts as a buffer in the Archean carbon cycle in geologic time scale.